# JOURNAL

OF

# THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

## PROMOTION OF THE MECHANIC ARTS.

---

**APRIL, 1863.**


---

## CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

*Papers on Hydraulic Engineering.* By SAMUEL MCELROY, C. E.

PUMPING ENGINES, No. 3.—(Continued.)

(Continued from page 13.)

BOILERS.—Having referred to *Pumps* and *Engines*, the third subdivision of our subject brings us to the discussion of the generators of power in the boiler room.

Of the three leading classes of boilers, stationary, marine, and locomotive, the latter has maintained its original type with much greater uniformity than the others, which show, as we also see in the case of pumps and engines, a strange diversity of opinion developed in numerous varieties of form.

Aboard ship and ashore, the simple process of water evaporation has been attained with the most varied forms of boilers, which would occupy a long list in the mere enumeration. As to the wagon shape, dome shape, and circular shells, with chambers, passages, water spaces, flues and tubes, spiral, upper returned, lower returned, double returned, vertical, inclined, and horizontal, in either steam or water conduits, our text books are full of examples, which go very far to show how much a simple process may be overlooked or overburthened in the zeal of invention or the fever of mechanical transpositions; and the practical comment experience has made on the greater part of all these devices is, that they fail to yield a reason-

able per centage of useful effect, and come far short, as a rule, of the natural law of evaporation.

The first requisite of a boiler is, that it should yield the greatest possible useful effect from its fuel combustion; the second requisite covers certain details of strength, durability, tightness, ease of access and repair, and compactness of form. These requisites should control the construction of boilers, and involve the general discussion of their operation and proportions; a discussion which may properly be directed to the *furnaces*, *interior form*, *exterior form*, and *appurtenances*, and some peculiarities of management.

*Furnaces.*—Chemistry demonstrates in clear and unequivocal language, that the process of fuel combustion is controlled by certain laws of combination, which must be carefully observed to attain maximum results. Without pausing here to quote the basis of the scientific theories on this subject, their lessons may be briefly summed up in the statement that the chemical union of the carbon and hydrogen of the furnace with the oxygen of the atmosphere, requires about 150 cubic feet, or 11·48 pounds of air for the perfect combustion of one pound of coal; and that from the difference between chemical *mixture* and chemical *unity*, combustion will be imperfect through the production of carbonic oxide in place of carbonic acid gas, and otherwise, if this *unity* is prevented. In how many boiler shops of the country is it understood, that practically the coal which goes upon the grates is the mere base of combustion, bearing a proportion of only one-thirteenth or one-fourteenth to the real agent, and that the vitality of each boiler depends on the length, breadth, and depth of the furnaces, and the supply of air through the ash-pits, grates, and other inlets, which may or may not be provided? The self-styled "practical" man believes that his boiler is made to burn coal; the engineer understands that it really burns air, and loses in efficiency by the per centage of air it fails to consume.

The subject of air supply to furnaces has been carefully investigated by numerous experiments in England, which, while more particularly directed to the prevention of smoke, have also made it plain that the ordinary grate openings are insufficient, and the surplus may be beneficially introduced in the furnace or the flue contiguous to it, provided the "mechanical mixture of the air and gas be continuously effected, before the temperature of the carbon of the gas (then in a state of flame) be reduced below ignition."* The investigations of Messrs. Prideaux, Clarke, Williams, and various other experimenters, confirm very fully what is theoretically obvious as to the ordinary grate opening, while the experiments with locomotive fire-boxes, both in England and this country, also demonstrate clearly the benefit of air supply above the grates, and directed towards the coal, rather than through it.

In many of the marine boilers recently built for the naval steamers, and some of our stationary boilers in water-works, as at Hartford and Brooklyn, and other instances, the fire doors have the inner plate

* C. W. Williams on Combustion of Coal, p. 89.

perforated with numerous small holes, which may be used or not, as a valve in the outer plate is regulated. This accomplishes the object to a certain extent. Various devices, in the use of feeding tubes, hollow grate-bars, hollow stay-bolts, and other means of air supply have been tried on the North River steamboats, and otherwise, in some cases with very satisfactory improvements. All these steps of progress, under the guidance of natural laws, must eventually lead to good results, when the laws themselves are clearly comprehended and followed.

On the matter of furnace proportion, and other like proportions, the text books on the steam engine, as a class, pretend to lay down certain fixed rules, based on what is called "nominal horse power." This basis is one of the mechanical absurdities of the day, which is so entirely disconnected from actual horse power, and is itself so variable in its self-selected standards, that the common sense of the profession in this country rejects it, and defines the measure of actual work and capacity for work, as the only correct basis of calculation. Where we know that the combustion of coal may be raised from 3 to 20 pounds per square foot of grate per hour, and the steam pressure from zero to 60 pounds and over, in the same boiler, we also understand the folly of fixing its power by the size of the cylinder to which it may be attached, itself susceptible of great fluctuations in actual work.

There is, however, to each furnace, as to its connecting parts which form the entire boiler, a certain action of maximum useful effect, which involves the real problem of study and experiment, and has been too much overlooked in the ambition for novelty in form and patentability.

Of the several devices for automatic fuel-feed and cleaning, which have been invented and put in operation, however correct in principle, none have as yet offered a safe substitute for the ordinary manual attendance; and for the present our boiler furnaces should be adapted to the conditions of this attendance.

We may say then, from considerable observation of actual results, that the ordinary length given to our furnaces of 5½, 6, and 6½ feet, is entirely too great for careful firing, and that in various experiments it has been found advantageous to brick up the lower end to about 5 feet. In this respect our experience has confirmed the rule of those English engineers who advocate smaller grate areas, and larger furnaces, the former, from the superior convenience of management, and the latter from the superior process of combustion. For similar convenience of management, comparatively narrow furnaces are advised, since the water spaces between them thus obtained, when made of proper width (in no case less than 4½ inches), form with their stud-bolts efficient sources of evaporation. It may also be taken as a rule, that the grates should be placed considerably below the flues, and not less than 30 inches below the crown sheet. Some remarkable improvements, from increase of bridge-wall, have been attained in special cases, and as to advantage in fire-box depth, every locomotive is a sufficient example, if the theory of combustion required further elucidation.

As to the strange varieties of grate-bars, which exist and occupy with their patterns rows of shelves in our pattern-rooms, it is enough to say that the bar should be narrow, with an upper groove to hold ashes for its protection from heat, deep in section, tapering to an edge, with liberal interspaces, and so bridged as to offer no hindrance to the use of the slice-bar or cinder-hook.

The use of thin, even fires, cannot be too strongly urged, from their effects on air supply and combustion. Four or five inches in depth give a careful fireman much less trouble than the barbarous masses of fuel too often seen in marine and stationary furnaces, and always improve a steam guage, while they reduce the coal account. We have reduced fires too often to put a steamer's boilers in racing order, not to have learned this experimentally, and there are abundant illustrations of the doctrine extant in our scientific treatises, if practice should seem to dispute it.

If fires are kept light, the corners carefully watched, the slice-bar judiciously used, and the supply regulated, the furnaces may be run for comparatively long periods in highly efficient state, without the wholesale cleaning expedient of "hauling" fires, which is objectionable in several respects, and more especially as to dirtiness and wastefulness.

It should be remembered also, in all cases of boiler design, that the furnace holds, in every boiler, an essential relation to the water evaporation; its fire surface, from the great intensity of its radiated and conducted heat, being by far the most effective in proportion to extent to any other heating surface. Aside, then, from this obvious propriety of a large combustion chamber, the question of heating surface dictates the use of roomy furnaces.

*Internal Form.*—Acting in connexion with the furnace or furnaces, by means of flues, tubes, and other conduits, the heated gases are conveyed in direct or broken lines to the chimney flue, or smoke stack, the aggregate length of travel, or amount of surface passed, differing materially in different types of boilers, each of which have, or have had, their warm advocates.

Although the object of each of the various forms or arrangements, internally as well as externally, has been to utilize most effectively the products of combustion in meeting the special objects of design, and in such cases as the locomotive boiler and others, certain special uses and requirements control the general design, it must be said of the various forms, as a whole, that they cannot all be correct in principle, or adequately fulfil the measure of their duty. It is true that different and local varieties of fuel may and should have some control over boiler design, as also in marine boilers the use of sea water and the want of space affect relative forms and positions, but above all special and local corrections, boiler construction and use ought to be regulated by general principles, applicable to the entire classes.

Looking upon the various forms of gas and steam passages and chambers, water spaces, and the like, as passing vagaries of construc-

tion, we may notice the relative claims of the more common and plainer internal forms, as to the question of flues and tubes.

We may take it for granted, also, that for greater advantage in strength, effective surface, and compactness of form, the flue boilers are to be preferred to the more primitive wagon-shaped and similar forms of boilers, which pertain to the days of ruder workmanship and more wasteful combustion, and have gone almost out of use.

The use, also, of the long, cylindrical, single flue boiler, seems to depend on certain habits or conveniences of use and construction, rather than any inherent advantage in form.

Notwithstanding the various arguments on the relative merits of slow or quick combustion, in which the Cornish and the Mississippi boilers are at strange antipodes of practice, it has been sufficiently demonstrated by observations we need not pause here to cite, that, except some slight allowances for differences in structure of coal, slow combustion is not economical, and that boilers of this type are not more economical than those of the marine or American type, of more compact form. We may assume, then, for the present, that the question of flues and tubes is important as pertaining to the general form demonstrated most efficient.

The transfer of the system of small horizontal tubes from the locomotive boiler, working with a steam blast, in which such tubes are matters of necessity, to marine and stationary boilers, operating under very different circumstances, appears to result from a desire to economize space; and the change of tube position to vertical lines, appears to result from a misconception of the action of vertical surfaces as steam generators. We say this with a reservation in favor of fire-engine boilers, or the Prosser boiler, and their class, which are expressly adapted to certain uses, or to superheating, or other collateral objects, having reference more generally to the recent patterns of marine and land boilers of multi-tubular form, which claim the advantages of large effective fire surfaces in reduced compass.

Taking any internal arrangement in consideration, it must be observed that by far the most active steam generator, with either flues or tubes, is the furnace surface. Experiment has shown, in locomotives, that two-thirds to three-quarters of the evaporation is produced at the fire-box, and observations on marine boilers (to which we may specially refer) tend to confirm this general statement.

It may also be said, that in reference generally to vertical surfaces as contrasted with the horizontal, vaporization depends on the quantity of heat taken from the plates, rather than that applied to them, and experiment confirms an inference deducible in theory, that the formation and slow discharge of steam bubbles on the former, prevents the free and proper return current of water, and interferes with surface efficiency. And, as to all classes of heating surface, efficiency is seriously controlled by the freedom of steam vent and of return water supply, as a modification of simple plate conduction of heat. From the use of vertical tubes or plates, two results then follow; first, that the generation of steam is hindered, from imperfect deli-

very of its globules, and, second, that the tubes are themselves liable to injury for want of adequate contact with the water. as a protective. Such fire surface cannot, therefore, be considered fully effective, and is not a correct measure of evaporative power.

In the group of horizontal tubes, the narrow water spaces and obstructed circulation for steam delivery and water return, also reduce the evaporative effect, and account for the rapid destruction of this part of the boiler, and its constant need of repairs. In fact, for both vertical and horizontal tubes, the chapter of repairs is sufficiently voluminous to justify a decided preference for more simple and accessible forms, afloat and ashore.

It is not only a matter of inference, that the plain upper arcs of horizontal flues of moderate size, with liberal water spaces, are more favorable to vaporization than groups of small and crowded tubes, while the avenues of passage for the heated gases from the furnace are also enlarged and improved, but it is a matter of experimental record in special cases, which further and more general experiment would undoubtedly confirm, that in actual evaporative results, flue boilers, judiciously arranged, exceed the multi-tubular. And they have, in addition, those advantages to which we referred in the outset, viz: strength, durability, tightness, ease of access and repair, with compactness of form.

*External Form.*—As connected with the internal arrangement of furnaces and flues, it may be taken as a rule, from advantages in steam generation and demand, from liability to priming, cost of boiler heating, equality of pressure, and other obvious reasons, that the water surface should be a minimum and the steam space a maximum. On this account in part, and also greater facility in construction, transportation, and bedding, strength of shells and braces, preference has generally been given to circular shells with steam domes, which elevate the supply steam pipe considerably above the water level, and when surrounding the uptake of the chimney, superheat their contents with most valuable effect.

As to proportionate length, in circular boilers with drop-return flues, and smoke flues below the shells, from experiments made on water works boilers with a high-range thermometer, which confirms the principle laid down by English authorities in other forms of boilers, we consider from three to three and a half times the diameter a liberal limit, which cannot be exceeded without detriment, and may admit considerable reduction.

In the drop-return boiler of the Hartford Water Works, which is conveniently accessible for temperature experiments, with a circular shell of 22·66 ft. length, a diameter of 7·5 ft., a furnace 7 ft. wide by 6 ft. deep, 4 upper flues of 18 ins. diameter by 14·33 ft. long, and 16 lower return flues, 13 of 8-inch, 2 of 9-inch, and 1 of 12-inch diameter by 12·25 feet long, the following temperatures were noted for an ordinary combustion of 6·4 pounds per square foot of grate, with a steam gauge of 25 pounds.

*Back Connexion.*

| | |
|---|---|
| At upper flue end, | 550° |
| At middle flue end, | 400° |
| At lower flue end, | 370° |
| In the chamber, | 334° |

*Return under the Boiler Shell.*

| | |
|---|---|
| At under side of boiler, | 284° |
| At centre of passage, | 240° |
| At side of passage, | 209° |
| At floor of passage, | 160° |

It was very evident from these results that the gases leaving the furnace at about 1900°, were retained too long within the boiler structure, which for a part of the flue travel was actually reducing the boiler temperature, at the ordinary and most convenient rate of combustion for the engine work. In this case, with the grates bricked over to an open area of about 23 square feet, and a total heating surface of 909 square feet, of which but 609 were calculated as effective, the proportion of heating to grate surface was $909 \div 23 = 39{\cdot}5$ to 1, the proportion of length to diameter being $22{\cdot}66 \div 7{\cdot}5 = 3$ to 1. As will be observed in the table given in this paper, this boiler ranks high in vaporization, and with a more rapid combustion would of course modify and improve the temperature of its lower flues.

*Appurtenances.*—Each boiler should have an independent safety valve, feed valve, blow off valve, and steam stop valve, in order to control its action properly, and these should be proportioned to the limit of duty required in steam and water supply. In flue boilers, on the back connexions, a plug-hole should be made opposite each flue centre, for convenience in examination and cleaning. Manholes and handholes should be made for the same use.

In addition to the ordinary pressure gauge and water cocks, each boiler should also have a glass water gauge, the latter furnishing an important index to internal operations. For experimental observations on quality of coal and other notes of consequence, a feed tank is valuable, as an appurtenance to the boiler room, in which the exact supply may be measured, measurements of evaporation by tank being much more accurate than by volumes of steam.

Although the ordinary use of auxiliary steam pumps is objectionable on account of cost in steam, to every group of boilers such a pump is valuable for special service and particularly in connexion with pumping engine wells and force mains, to which they should be attached.

In boiler-feed, of course the supply should be taken from the hot-well, and where the feed pipe can be carried through the boiler connexion, some benefit may be derived from the heat imparted; but the use of small pipes, or coils of pipes, with abrupt turns, is to be avoided, as being much more expensive in friction than any apparent gain in temperature can compensate, the relative heat of feed water being less

important than is generally supposed, within the range of a few degrees.

The importance of bedding a boiler on cradles, is now commonly recognised, for convenience of access, inspection and repair to the lower shell, and the necessity of avoiding any strain from improper supports, is obvious.

From the important losses by radiation and leakage, perceptible or imperceptible, the value of careful covering by non-conductors may be strongly urged, as sources of increased efficiency and economy, and as regulators, to a certain extent, of evaporative action and tensile strain.

Tight and permanent floors, substantial walls and roofing for the boiler room, liberal working space for the firemen, selected firing tools, separate chambers for the coal and coal screens, metallic troughs for the hot cinders and ashes when hauled, and other like conveniences, not only promote the comfort of the attendants, but also advance that care of details, which always reduces the aggregate expense account where so much depends on manipulation and oversight. All such expenditures are admirable investments.

*Fuel.*—As between the use of wood and coal for combustion, the former, except for convenience in starting fires, bears no comparison in quality. Between bituminous and anthracite coal, experience in this country has established the superiority of the latter for stationary and marine uses, as to compactness and firmness of structure in the coal bunker and on the grate, specific gravity, cleanliness, steadiness of combustion, and general evaporative power. While there may be special varieties of the former, of great value when properly used, and with admirable constituents of quality, the white-ash anthracites as a class, are much more economical in quality, and such veins as those of the Scranton and Schuylkill valleys, take the front rank. And yet what is now generally admitted, was as generally denied a dozen years ago.

The theoretical value of one pound of coal, of good quality, as determined from its constituents of carbon and hydrogen, may vary from 13 to 15·5 pounds of water evaporated from 212°. As a general rule, among the complex stationary and marine boilers in use, not more than one-half this result is realized in practice, and sometimes not more than one-third.

Sewell (*Steam and Locomotion*, p. 99), refers to a range of results from 10·74 to 12·89 pounds, obtained by Cornish engineers in 1840 and 1846, and mentions other results of 13·48 pounds on an experimental boiler, 11·428 pounds from 212° from the combustion of 11,730 pounds of coal, at the Par Consols mine, while other instances of similar rates of practical evaporation on record in engineering works, furnish a severe comment on the enormous daily waste of fuel in our workshops and engine houses, and at sea.

## BOILER EXPERIMENTS.

| Location. | Varieties. | Size. | | Square Feet Surface. | | | Tubes or Flues. | | Pounds Water Evaporated. | | | | Coal. | | Time. | No. of Boilers. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Fire. | | | | Indicator. | | Tank. | | | | | |
| | | Length. | Diameter. | Grate. | Nominal | Effective | No. | Diam. Inches. | From | From 212°. | From | From 212°. | Per sq. ft. grate per hour. | Total used. | Hours. | |
| **Flue Boilers.** | | | | | | | | | | | 80° | | | | | |
| East London Water Works | Wagon head | 24·16 | 5·91 | 37·26 | 588 | | 1 | 36×30 | | | 8·3 | | 10·89 | | 82 | 1 |
| | Cornish | 27·83 | 6·5 | 224 | 3192 | | 4 | 46 | | | 8·52 | | 4·68 | | 504 | 4 |
| | " | | | | | | | | | | 8·42 | | 2·59 | | 514 | 4 |
| Old Ford | " | | | | | | | | | | 8·3 | | | | | |
| Loams Engine | " | | | | | | | | | | 9·16 | | | 1568000 | 6 mos. | |
| Par Consols | " | | | | | | | | | | | 11·43 | | 119700 | | |
| | | | | | | | | | 100° | | 100° | | | | | |
| Jersey City Water Works | " | 34 | 7 | 60·66 | 2450 | | 3 | 52 | 7·49 | | 9·77 | | 4·96 | 1806 | 6 | 3 |
| | | | | | | | | | 7·48 | | 9·88 | | 4·84 | 3524 | 12 | 3 |
| U. S. Steamer "Fulton" | Drop Return | 22 | 10·5 | 112 | 2200 | | 12 | 16 | 8·77 | | | | 20· | | 5·3 | 2 |
| Smithery, N. Y. Navy Yard | " | 24 | 4 | 19·25 | 380 | | 5 | 12 | 4·97 | | | | 14·08 | 9891 | 35 | 1 |
| | | | | | | | | | 6·02 | | | | 12·42 | 9896 | 39 | 1 |
| | | | | | | | | | 6·15 | | | | 11·92 | 8650 | 35 | 1 |
| Hartford Water Works | " | 22·66 | 7·5 | 23·12 | 909 | 609 | 4 | 18 | 6·09 | | 10·61 | | 6·91 | 400 | 2·5 | 1 |
| | | | | | | | | | 8·39 | | 10·96 | | 5·08 | 1117 | 8·5 | 1 |
| Brooklyn " | " | 30 | 8 | 112·5 | 4064 | 2709 | 12 | 18·5 | 9·27 | | | | 11·86 | 34773 | 26· | 3 |
| Cambridge " | Upper Return | 20 | 4·16 | 7·15 | 488 | | 20 | 4 | | | 10·89 | | 5·04 | 542 | 12·25 | 1 |
| 10 Ocean Steamers, av'ge bituminous coal | | | | | | | | | 5·14 | | | | | | | |
| 9 " " " anthracite coal | | | | | | | | | 7·23 | | | | | | | |
| **Tubular Boilers.** | | | | | | | | | | | | | | | | |
| Prosser Patent | Vertical | 8·75 | 2·5 | 2·25 | 112·8 | | 100 | 1·25 | 8·58 | 9·53 | 9·93 | 11·03 | 14·28 | 257 | 8 | 1 |
| U. S. Steamers—"Niagara" | " | 21 | 13·66×15 | 484 | 12817 | | 8160 | 1·81 | 7· | | | | 14·25 | 6940 | 1 | 4 |
| | | | | | | | | | 9·05 | | | | 8·8 | 4059 | 1 | 4 |
| " "Michigan" | " | 16·66 | 9·5×9·2 | 90 | 2690 | | 1504 | | 5·57 | 6·20 | 8·40 | 9·36 | 3·80 | 2667 | 72 | 2 |
| | | | | | | | | | 4·94 | 5·50 | 7·86 | 8·76 | 4·11 | 24600 | 72 | 2 |
| | | | | | | | | | 6·26 | 6·98 | 9·06 | 10·10 | 5·21 | 33766 | 72 | 2 |
| | | | | | | | | | 5·76 | 6·42 | 8·60 | 9·60 | 6·28 | 40740 | 72 | 2 |
| | | | | | | | | | 6·69 | 7·45 | 8·17 | 9·10 | 9·51 | 61657 | 72 | 2 |
| | | | | | | | | | 6·91 | 7·70 | 7·40 | 8·25 | 11·41 | 73944 | 72 | 2 |
| | | | | | | | | | 7·23 | 8·05 | 7·44 | 8·29 | 18·52 | 120024 | 72 | 2 |
| " "Susquehanna" | " | 15 | 11×13·5 | 169 | 5851 | | 2740 | 1·81 | | 9·14 | | | | 4200 | 4 | 2 |
| " "San Jacinto" | " | 21·25 | 11×11·25 | 108 | 3653 | | 1620 | 1·81 | 7·89 | 8·80 | | | 8·92 | 92512 | 96 | 1 |
| " " | Horizontal | 21·25 | 11×11·25 | 108 | 2663 | | 414 | 2·73 | 6·82 | 7·61 | | | 9·68 | 100436 | 96 | 1 |
| H. B. M. Gun Boats | | 14 | 4 | 29·25 | 864 | | 96 | 1·5 | 7·47 | | | | | | | |
| Ellis' Patent | " | 13 | 4·75×7 | 14 | 563 | | 50 | 2·5 | | | 9·07 | 10·01 | 13·57 | 1900 | 12 | 1 |

Authorities:—Sewell's "Steam and Locomotion," Prideaux on "Fuel," C. W. Williams on "Coal Combustion," Armstrong on "Boilers," Stewart's "Naval and Mail Steamers," Isherwood's "Precedents," &c.

*Duty Tests.*—In various experiments, recorded from time to time on pumping and other engines, it has been customary to bring the boilers up to their state of effective operation, and commence a set of parallel observations, at the close of which an attempt is made to leave them in precisely the initial state assumed. The objections to this process in all short experiments are important where close measurements of coal are needed, and have been discussed at length in former pages of this *Journal*, more particularly on page 239 of vol. xxxv., 1858, in which a different method is presented, by taking the boilers with fires hauled after being properly warmed up, and hauling fires at the close of the experiment to determine the value of the grate contents, in coal, cinder, and ashes, accounts being thus kept of all the fuel used from the time of starting the second fires.

*High Steam.*—It is well understood in the world of practical engineering, and is confirmed by correct theory, that it is much cheaper to make high steam than low steam, from the saving in fuel to produce equivalent power, the improved condition of heat convection in the boiler contents, the comparative losses by external radiation, and the resultant increase by superheating. The favorite method of "making up time" among first class locomotive engineers, by running up the steam gauge at the stations, and shortening the cut-off notch, illustrates forcibly the correctness of this source of economic increase of power, applicable to all kinds of boilers. It is a matter of demonstration, that 90·7 pounds of coal, making steam at 60 pounds, are worth 100 for steam at 15 pounds, or about atmospheric pressure, and that in each of the other sources of advantage named, the issue is decidedly favorable to the higher pressures. It is also true, that up to a certain range of heating, (550°,) iron boiler plates increase their strength, while below a certain tension, which is far within the limits of ultimate strain, a boiler is as safe from one pressure as another, in reference to the usual sources of danger from disruption and explosion, which rest so much on careful attendance. As to safety under working strain, we believe that there is little to be feared from steady pressure, even at ranges which may be called excessive, and have slept over 180 and 200 pounds of steam, after some study of the attention of the firemen to the gauge-cocks, confident of as great safety as over one-fifth or one-tenth the gauge. We do not, of course, advocate such a pressure for pumping engine boilers, but even in cases where a close throttle must be adopted, we certainly do advise something like the Cornish standard of pressure, from 45 to 60 pounds. The effect in duty, demonstrated by numerous trials on the Brooklyn boilers, of an increase from 9 to 18 pounds pressure, was too emphatic to leave any room for question, even as to so unreasonably low gauges.

*Superheating.*—Some positive means of giving all boiler steam the benefit of this process, should be adopted. Among all the extravagant claims of enthusiasts on this subject, which have induced a general re-action, too much has been proved as to its benefits to be lightly disregarded, up to a certain moderate range of application;

and by this we mean an application more distinct and more clearly defined than the ordinary process of superheating common to boilers with chimney uptakes or steam domes. If saturated steam, by the addition of from 7 to 75 degrees of heat, will be expanded from 10 to 30 per cent., as some experiments have it, and such increment of heat can be conveniently taken from the wasted gases of combustion, there is great propriety in the application; and granting the special claim to be erroneous as to gain, if the steam can be fortified against the steam-pipe, chest, and cylinder radiations and condensations, so as to show the boiler pressure on the indicator cards, even this result is worth the slight cost of attaining it. In most of our engines, the losses between the cylinder and boilers are formidable in their per centage of coal waste.

*Improved Conduction.*—It is urged by some authorities and endorsed by experiment, that the use in boiler flues, of conducting pins about 3 ins. long, projecting downward, into the heated currents, by presenting much more favorable points of heat transmission than the smooth surface of the flue sheets, improves the evaporation. The application is simple and is justified by the conditions of furnace flue action.

*Summary.*—The general lesson taught by the diversified forms and operations of boilers, and the principles of their action is, that the great majority come far short of available natural results, from imperfect design and management, and that the simpler forms are practically and theoretically to be preferred.

In the table on page 225, and which is taken from various sources, rather as a general illustration of such results, than as collated evidences of any special theories, will be found with some study, a running comment on relative rates of combustion, relative grate and heating surface, relative efficiency of tubes and flues, and general proportions.

Its principal use, however, or the use of such a table as we should like to present, if present pressure of other occupations did not prevent, is to show the need of a more systematic investigation of a subject which is vital to all the mechanical operations of the day, and the general adoption of such rules of design and manipulation as shall improve the present wasteful experience. A single thought of the immense sums of money spent in fuel annually in our land, and the effect of even a moderate per centage of improvement, brings the necessity of some organized and effective movement in this direction forcibly to view.

Of this particular tabulation, however, it cannot be claimed that its special experiments have the force of absolute demonstration, since each is based on special and local conditions as to quality of fuel, manner of firing, correctness of coal account, rate of combustion, and other modifications which prevent a rigid deduction of any rule of proportion.

The most complete group of experiments on the "Michigan" made under the special charge of one of the most accomplished engineers of the day, and on boilers which are presented as perfections of multitubular model, are yet anomalous in their several results, and demon-

strate a fact practically known to all thorough-bred engineers, that with the same conditions of experiment results may be greatly varied by differences in manipulation. These experiments, made to determine a very different question, really became observations on relative facilities of combustion and evaporation in the same boilers.

The experiment on the "Susquehanna," as has been shown in a paper above referred to, were too carelessly made to secure correct results. Those on the "San Jacinto," made expressly to determine the relative merits of tubes and flues, just as expressly prove the value of results obtained under conditions of design and operation, clearly unfavorable to the latter.

While, then, a critical analysis of each experiment detailed, would modify its relations to the general aggregate, there can be no question, we think, that the aggregate itself is clear and plain on the advantages of simplicity in form, as to the desideratum of power, compactness, access, and other special requirements for boiler use, and the results obtained from the boiler of such construction are too prominent to be overlooked or denied.

There are several other points on this general subject which probably should be presented to complete the hurried sketch herein attempted, but cannot now be given from want of space and time.

(To be Continued.)

---

## *International Exhibition.*

From the London Mechanics' Magazine, December, 1862.

CLASS X, SECTION A—JURORS' REPORT.

(Continued from p. 165.)

In the space beneath the caisson compressed air was used to expel the water to allow the men to work, and it was also employed to force down the cylinders to the requisite depth, the air pumps being worked by a steam engine from above. Within the caissons workmen were employed to remove the gravel, &c., from under the exterior edges as they descended, whilst the great mass of the material, which was cast by hand to the centre, was removed by means of the dredging apparatus worked by a steam engine upon the platform above. The novelty and the chief cause of the efficiency of this apparatus consisted in the centre cylinder being open to the atmosphere at the upper extremities, and plunged in the water at its lower end, by which means the great mass of the material could be removed by the dredging apparatus much more rapidly and economically than if all the material had been hoisted in buckets through the air-locks, in the usual closed cylinders. The caissons were thus carried down to the requisite depth below the ordinary level of the Rhine most successfully, in a much shorter time, and at infinitely less cost than by the usual method, and the piers were founded at such a depth below the scour of the current, as to give every reasonable guarantee of their stability. The superstructure, which was executed under the supervision of M. Keller, the

engineer-in-chief, and the Baron Kagenech, engineer of the Grand Duchy of Baden, does not offer any remarkable features, although it has been well executed and perfectly answers the purpose for which it was intended. To M. Vuigner, chief engineer of the Eastern Railway Company of France, and M. Fleur-Saint-Denis, engineer of bridges and roads, and author of the project, have been awarded a collective medal, for the ingenuity of design for these piers and foundations; and to Messrs. Castor, the contractors, also a medal, for the intelligence of their arrangements and the successful execution of this work, and also for a similar application at the bridge of Argenteuil.

The next bridge worthy of mention is that over the Garronne, at Bordeaux, to connect the Orleans Railway with that of the South on the other side of the river. This extensive work was originally designed by the late M. Alfred Bommart, engineer-in-chief of bridges and roads, and it was after his decease carried into effect under the direction of M. Surell, engineer-in-chief of bridges and roads, by the enterprising contractors, Messrs. Pauwels & Co., under the superintendence of M. De la Roche-Tolay, engineer of bridges and roads, chief engineer of the company, and M. Regnault, engineer of bridges and roads, resident engineer. The total length of this bridge is 500 metres, and it consists of seven openings, the two extreme spans being 57⅓ metres each, and the five other spans 77½ metres from centre to centre of the piers.

The superstructure is formed by wrought iron girders upon the trellis principle, which require no further remark, than that they are well executed. The foundations of the piers were executed by means of cast iron cylinders, which served as air chambers, having the air-lock on a platform attached to the upper part of each cylinder, and which was removed, as occasion required, to replace another length of cylinder. These cylinders were sunk in pairs, side by side, by the compressed air system of M. Triger, and the pressure was given to the cylinders by hydraulic presses. The bed of the river was composed of mud and sand, through which the cylinders were forced, with a depth of water varying from 7 to 13 metres, a current of from 2 to 3 metres per second, and a strong tide rising 6 metres. These were some of the difficulties to be contended with, and which were very successfully overcome by the intelligent foresight of the engineers and the practical experience of the contractors. To MM. A. Bommart, De la Roche-Tolay, and Regnault, the engineers, has been awarded a collective medal for the boldness of the design, and the simplicity and economy of construction of this bridge; and the same recompense has been also awarded to Messrs. Pauwels & Co., the contractors, for their intelligence in carrying into effect the designs of the engineers, and more especially for improvements in the application of hydraulic presses for forcing down the cylinders, on the system invented by Messrs. Fortin-Hermann & Co.

In addition to the above bridges, or viaducts, there are models of several others, of which the superstructure, piers, and abutments, are of masonry. The bridge at Chaumont, by M. Decomble, engineer of

bridges and roads, although displaying nothing original in the design, or construction, is well executed, and is creditable to the engineers and contractors by whom it was designed and constructed.

This important work, which is nearly 700 metres in length, 53 metres in height, was constructed in 14 months; its execution is perfect, and the general effect is very good. To M. Decomble, the engineer entrusted with the execution of the work, has been awarded a medal; and to Messrs. Parent & Shacken, contractors, and Monsieur Gourdin, their engineer, honorable mention for their intelligent co-operation and the excellent arrangement of their executive staff.

The viaduct of Nogent, on the line of railway from Paris to Mulhouse, consisting of three arches, each of 50 metres span, and of 30 arches each of 15 metres span, all in masonry, deserves mention, as a well designed and excellently executed work, for which honorable mention was awarded to M. Pluyette, engineer of bridges and roads, entrusted with the execution of the work.

The bridge of Napoleon, at St. Sauveur, in the Pyrenees, consists of one semicircular arch of 42 metres span in masonry. The foundation presented great difficulty in consequence of the mountain torrents swelling the course of the Cave de Pau. To M. Marx, engineer-in-chief of bridges and roads, and to M. Bruniquel, resident engineer, were awarded collective honorable mention for the good execution of this boldly conceived work.

There must also be mentioned the successful execution of a large bridge over the Vistula, near Dirschau, designed by M. Lentze, for which, and for the ingenuity of the inclined planes on the Oberländische Canal, designed by M. Steenke, medals have been awarded to the Minister of Commerce of Berlin, and to the Royal Engineer Works at Dirschau (Zollverein, 1338). To Messrs. Schnirch & Fillunger (Austria, 626), for the bold and successful bridge over the Danube Canal at Vienna, and to the State Railway Society (Austria, 628), for their good structure, introducing improvements by Rupert in lattice bridges, and for the excellence of execution of these and other important works, medals have been awarded.

To Messrs. Klett & Co., of Nuremberg (Zollverein, 180), a medal has been adjudged for the boldness of the design and the successful execution of the railway bridge across the Rhine, at Mayence, on the system introduced by M. Pauli. This bridge has a very large span, and is of singularly simple construction, offering great facilities for repairs and for keeping in order, by painting, &c., all parts being accessible.

To the Commissioners of New Brunswick was awarded honorable mention for the utility of the bridge works, of which models were shown.

II. Harbors and Docks.—With regard to this department there are several works particularly worthy of notice; and amongst the most important must be mentioned the great "digue," or breakwater of Cherbourg. The history of this great work is very remarkable, and the structure itself presents a great variety of operations, equally

instructive from their failure and their success. There have been tried here consecutively the ingenious yet abortive idea of the wooden cones filled with small rubble stone—the small rubble upon the *pierre perdu* system, which was equally unsuccessful—then the larger rubble system—and finally the béton and masonry systems, by means of which this great work has been eventually completed. All these plans exhibit considerable ingenuity and skill; nevertheless, it must be admitted that the construction of this great work, at the outset, evinced great deficiency in the knowledge of those first principles which should guide the engineer in the construction of works of this nature and magnitude.

The breakwaters of the Carthaginians at Tyre and Sidon, of the Greeks at Athens, Halicarnassus, Ægina, and in numerous other places, as well as those of the Romans at Ostia, Civita Vecchia, Ancona, Naples, and other ports in the same vicinity, show that the simplest and most economical mode of constructing barriers, or breakwaters, to resist the violence of ocean storms, was by throwing down, or depositing, rough undressed blocks of stone, as raised from the quarries, and allowing them to form their own slope, or inclination, by the action of the waves, until finally the masses, thus thrown down, become settled, when their permanence was further augmented by the growth of seaweed and the drift of the sand into the crevices; so that these works have remained unaltered until the present day. The experience, however, derived from these works does not appear to have been taken advantage of until within a comparatively recent period, and hence the variety of systems introduced in the construction of the breakwater at Cherbourg. In fact, instead of starting from the point of demonstrated success, a comparatively tentative process would appear to have been pursued; whereas, if the knowledge of the past had been taken advantage of, much trouble and cost would have been avoided.

It is to be regretted, in an engineering point of view, that the position of the breakwater should have been determined by purely military considerations, which demanded a direct line between the forts Pelee and Querqueville, thus materially reducing the extent of the roadstead.

The history of this great work, as given in the works of M. de Cessart and MM. Alexis de Tocqueville, Cachin, and Bonnin, &c., as well as in the "Annales des Pont set Chaussées," conveys much information. Due honor should be given to the several able engineers-in-chief and to their subordinates, who have brought the work up to its present satisfactory state. The names of the chief engineers are:—

Captain la Bretonniére, Royal Navy, 1777 to 1782.

M. de Cessart, inspector of bridges and roads, 1782 to 1792.

M. Lamblardie, inspector-general of bridges and roads, 1792 to 1793.

When an interval occurred until 1802, when the works were resumed.

Le Baron Cachin, inspector-general of bridges and roads, 1802 to 1823.

M. Fauques Duparc, divisional inspector of bridges and roads, 1823 to 1838.

M. Reibell, inspector-general of bridges and roads, 1838 to 1853, when the work may be said to have been completed, and to the latter eminent engineer and his able coadjutors, MM. Virla, Mahyer, and Bonnin, engineers of bridges and roads, and to their predecessors and assistants, a collective medal has been awarded, on the completion of this important work, after so many years of persevering efforts, due to the judicious use of all the resources induced by the progress of marine construction.

It is not any detraction from the merit of the many able engineers who have been employed upon this great work, to say that every allowance must be made for the want of knowledge and experience which existed at the time when it was commenced; and as a matter of scientific inquiry, it is most interesting to place on record all the facts of the progress, and to compare the modes employed with those of the present day.

The new port of Marseilles is a great work, which has been planned and executed upon an extensive scale by M. Pascal, engineer-in-chief of bridges and roads. It is situated to the eastward of the old natural harbor, formed by a creek, which was taken advantage of, and around which the town sprung up. The new artificial harbor consists of a series of wet docks, or basins, formed by moles, or breakwaters, constructed in the open sea. They run parallel to the shore, and communicate with each other by openings and locks through the cross walls which separate them from each other. The outer, or boundary sea wall, connecting the whole system, answers the double purpose of a breakwater on the outside, and a quay wall on the inside; and at each end of these docks is an outer, or entrance harbor, so that vessels can use either, according to circumstances, and can pass from one to the other, as convenience may require. There is, also, a connexion with the old harbors. The general design of this harbor is good, but the sea entrances are scarcely sufficiently protected against the swell of the sea during storms. The details of the construction are entitled to considerable credit, for every class of materials has been utilized to the greatest extent; the smallest stones being used in the interior and the largest in the exterior, where the face is exposed to the greatest action of the sea. The outer face, or sea slope, of the great exterior breakwater is protected by large masses of béton, formed into artificial blocks, each weighing from 25 to 30 tons, which are said to be immovable by the most violent action of the waves; and so far they have resisted the disintegrating effects of the sea and the atmosphere and with success, although further experience is necessary, before the béton masses can be pronounced to be indestructible. Great credit is due to the French engineers, amongst the earliest of whom may be mentioned M. Poirel, for reviving this ancient system of building, and to M. Pascal, the engineer-in-chief, the award of a medal is made for the methodical and scientific direction of these important and extensive works, including the utmost economy, without sacrificing the ex-

cellence of construction, and to Messrs. Dussard, Brothers, of Marseilles, the contractors, honorable mention for their intelligent assistance in the execution of important parts of the works.

The lock-gates of the docks, at the port of St. Nazaire, are specimens of timber constructions of very large dimensions, not requiring the use of any logs of large scantling; and M. Watier, engineer of bridges and roads, the author of the design, and the constructor of the first gates on this system, to whom honorable mention has been awarded, is entitled to great credit for the boldness of the design and the ingenuity of the construction, in which he was strenuously supported and succeeded by M. Leferne, engineer of bridges and roads. The general works of the port being first under the direction of M. Jegou, and subsequently under M. Chatoney, engineers-in-chief of bridges and roads.

The lock of the citadel and the graving dock of the Eure basin at Havre are important works. The graving dock and its entrance locks are designed upon a very large scale, with the view of receiving the vessels of heavy tonnage engaged in the trade with New York; the depth of water on the cill being 8½ metres at low water of spring tides, and the locks being 30½ metres in length. The construction of the walls is of the best quality, and much ingenuity has been exhibited during the progress of the works, as well as in the general designs for the extension of the port of Havre, for which there has been awarded a collective medal to M. Bouniceau, engineer-in-chief of bridges and roads, and to MM. Bellot and Lemaitre, resident engineers.

(To be Continued.)

---

## *Iron Piers for Railway Bridges in Alluvial Districts.*

From the Lond. Civ. Eng. and Arch. Jour., Oct., 1862.

(Continued from page 170.)

As it is considered that uniformity of parts, as far as practicable, is of as great importance in bridge work as in other mechanical structures, a uniform span of 60 feet is adopted for all the iron bridges on the Bombay and Baroda line, this being considered the most economical in reference to the general heights of the piers. One end of each girder is fixed on the pier, while the other end is left free to move, and carried on a pair of small rollers to allow of expansion and contraction. The weight of the entire 60 feet superstructure for a single line of rails is 24 tons, being 8 cwt. per foot run, and the cost is about £400. In the construction of piers adopted for inland rivers with deep water, say 20 to 50 feet, but not tidal, where the current is always in one direction only, here the oblique piles, acting as struts, are required only on the lower side of the bridge, and the timber fenders only on the upper side. In the case of piers for inland rivers with shallow water of not more than 20 feet depth, the oblique piles can be dispensed with altogether. Where there is a rock foundation, the screws are omitted, and the piles are simply let into the rock about 2 feet and filled round with cement, allowing of great rapidity of erec-

tion in this case. The position of the roadway may be either between the main girders, or upon the top of them. The upper position is preferable for the roadway, because it combines the effect of both the main girders in resisting forces that tend to produce buckling of the compression beams. The upper or lower position of the roadway, however, is decided by the amount of headway under the bridge, or the clearance between the bridge superstructure and the highest known flood level of the river, which should not be less than 5 feet. In every case the power of the compression beams to resist buckling is made ample, and a horizontal diagonal bracing of T iron is provided between the cross girders carrying the roadway, continued from pier to pier; and where the roadway is on the top of the main girders, oblique stays are added, to secure the requisite stability and freedom from vibration in the roadway and girders.

The use of animal power was adopted in screwing down the piles of the great Nerbudda bridge, where a large part of the river bed is uncovered at low water, and it is only in such situations that animal power has been made available direct by means of a long lever. The general practice has been, where the foundations are not always under water, to hoist the piles into the proper position by shear legs, and hold them in this position by guides whilst they are screwed into the ground by a crab winch acting on the end of the lever; but where the ground is always covered with water, a staging has been erected on timber piles surrounding the site of the pier. Latterly the principle of floating rafts has been successfully adopted instead of fixed staging.

Of the piers nearly half were supplied by the Horseley Iron Co., Tipton, and the rest by the Victoria Iron Co., Derby. There is always a difficulty in carrying cast iron safely across the sea, from the great risk of breakage in shipment and in conveyance by land, as well as the chance of disasters at sea; but in the case before us altogether only about 5 per cent. of loss from all causes in the cast iron work occurred, which is a smaller proportion than usual in similar cases. The first part of the superstructure was made by Messrs. Kennard, at Crumlin; but the greater portion by Messrs. Westwood, Bailey and Campbell, London Yard, Isle of Dogs. For the erection of the work in India, the engineers and foremen alone were sent out from England, and all the other workmen employed were natives: Colonel Kennedy states that the natives make good workmen in a very short time, and then get on rapidly. As a consequence of the additional employment, the price of labor has been doubled by the railway works throughout the district traversed by the line.

The practice of cutting down the dimensions too fine in such structures is to be avoided, and a liberal margin ought to be left beyond the calculated strength, to allow for strains which could not be taken account of with the same accuracy as simple transverse and longitudinal strains. Buckling is a frequent source of extra strain, particularly where there is any considerable depth of girder, and is therefore required to be carefully provided against by increasing the size of the

sections and arranging the iron in such a form us would enable it best to resist buckling under compression. In the girders employed, all the bars subject to compression were made of a cross shape in section; and the greatest strain, either of tension or compression, on any part of the girders amounted to only $3\frac{3}{4}$ tons per sq. inch under the heaviest practical load. The greatest longitudinal motion observed in 24 hours amounted to $\frac{3}{16}$ inch in one span of 60 feet. In the dimensions of the girders great allowance was made to provide against buckling and the strains produced by concussions, and there were only a very few places at which the strain ever came up to the maximum of $3\frac{3}{4}$ tons per square inch, while every where else it was much below this amount, so that the strains never approached the elastic limit of the iron.

The pile lengths were cast vertically, and the joints were generally cast with sufficient accuracy to go together without any fitting; but where necessary they were chipped to a level face, and care was taken to insure a uniform thickness of metal throughout the flanches. Every piece of iron work was dipped when hot in a bath of linseed oil, and had afterwards two coats of good oil paint. After erection, frequent and thorough painting are relied upon for keeping the iron from rusting. From an examination of several old iron structures, it has been found that the cast iron generally stood well, but the wrought iron shows evidences of corrosion after it has been up about 20 years, and it could never be relied on unless frequently painted or otherwise protected. The prevention of iron from rusting is a question of general importance, and every encouragement should be given to investigation of the subject, with a view to obtaining some really permanent protection. It is clear that even with its present liability to oxidation iron is decidedly the cheapest material for large bridges in general, particularly in alluvial districts: but its durability and renewal are dependent mainly on its thorough protection from oxidation. The object to be sought is not simply to secure the best protection out of a number of modes, of which all may be defective; but to arrive at an absolute means of preservation, if that be possible.

Tar has proved a very effective material for preserving the bottoms of iron ships from rusting, and is applied also inside vessels. On the Clyde large ships of 2000 or 3000 tons burden are protected inside with a coat of varnish made from purified coal tar, which is found a very efficient protection. A clean surface of the iron for laying on the varnish is all that is required, and it has a fine polish; the coat lasts 7 or 8 years when protected by a lining of wood work in front. The varnish may be laid on cold, and the smell is all gone in a few days; the cost is much less than red lead paint. This plan has also been applied to the inside of steam boilers, where the uptake from the furnace passes through the steam room of the boiler, and it prevents oxidation and scaling of the iron from the action of the steam for a long period: it ought, therefore, to be suitable for such structures as the bridges described.

The lower lengths of the piles are filled with concrete, which renders them solid inside, so that each pile stands on a solid foundation of $4\frac{1}{2}$ feet diameter. Much accuracy was required in getting the piles

correct in level: this was managed by screwing them down a little further if necessary; and as there are four lugs at each end of the several lengths for attaching the diagonal bracing, the level could be adjusted to one quarter of a revolution of the screw. Where the piles stood on a rock foundation, a piece of the required length was cut off the bottom of the lowest length, leaving the flanch at the top for bolting to the next length; or else the rock was cut away deeper to get the proper level. A few cases occurred of a pile being broken in screwing down, and it was then very difficult to get the screw out again; this was one of the chief difficulties that had been met with in erecting the bridges. At the Nerbudda bridge the sudden abandonment of the work, caused by an outbreak of cholera and followed by monsoon floods, left some single piles unsupported, which were broken; and one or two of these could not be got out again, so that it became necessary to alter the spans in two cases, selecting fresh sites for the piers, in order to get clear of the broken piles. Rapidity of fixing is of special importance in India, for on account of floods and storms the working year for such operations can be reckoned at only about eight months; and the facility of erection with this construction of piers and superstructure is so great, that by beginning at both ends at the same time, they could now bridge the broadest river in a single season.

---

### *Solid Matter contained in the Waters of the Hooghly.*

From the Lond. Civ. Eng. and Arch. Journal, Jan., 1862.

In regard to the amount of solid matter contained in the waters of the Hooghly, it was stated, that although Major Rennell had in his "Memoir of Hindostan" estimated the water of the Ganges to consist of one-fourth part mud, yet in other writings he had given it as only the $\frac{1}{200}$th part. This agreed more nearly with Mr. Piddington's experiments, which showed the quantity to be the $\frac{1}{615}$th part, and with the Rev. Mr. Everest's, who made it the $\frac{1}{855}$th part, both during the rainy season. The Nile contained $\frac{1}{120}$th of its bulk in mud, and the Humber $\frac{1}{180}$th, of which latter, sand formed about 75 per cent. But even allowing that 78,000,000 cubic yards of solid earth were deposited yearly in the Hooghly and its estuary, this would only give $1\frac{1}{2}$ inch in depth over an area of 600 square miles, included within the 3-fathom contour; and if the area was extended to the 5-fathom contour, and embraced also the inlet of the Hooghly, then the area would contain 1200 square miles, and the deposit would only amount to $\frac{3}{4}$-inch in depth.—*Proc. Inst. Civil Eng.*

---

### *On the Construction of Iron Roofs.* By J. J. Birckel.

From the London Artizan, September, 1862.

(Continued from page 153.)

So far we have investigated the conditions of stability of those kinds of triangular roofs most generally adopted, and which we can best recommend to our readers. We purpose to treat of circular roofs in a separate paper, and have designedly omitted the consideration of them in the present investigation.

Having learned how to determine the relative amount of stress upon the various parts of a principal, we will now define the total amount of pressure which the roof, under certain circumstances, may have to resist. Among the accidental sources of pressure, those of wind and snow form the most important items, because both may occur simultaneously. According to General Morin's observations, snow may accumulate upon a roof to the depth of 20 inches, and as its weight is $\frac{1}{10}$th that of water, the pressure due to this element would be about 11 lbs. per square foot; the same philosopher, however, thinks that one-half this amount will make ample provision; we will keep on the safe side, and suppose it to be 6 lbs. per square foot.

Respecting the wind, we have subjoined a short table of the pressure produced at various speeds upon a plane of resistance supposed to be at right angles with the direction of the wind.

| Speed in feet per second. | Pressure per square foot. | Speed in feet per second. | Pressure per square foot. |
|---|---|---|---|
| ft. in. | lbs. | ft. in. | lbs. |
| 10 0 | 0·2 | 46 0 | 4·7 |
| 13 9 | 0·6 | 65 7 | 9·6 |
| 26 3 | 1·5 | 131 0 | 38·4 |
| 35 7 | 2·8 | | |

General Morin, from whose work the above data are quoted, thinks that a direct pressure of 3 lbs. per square foot is quite sufficient to reckon upon, but English engineers differ from him on that point, and make allowance for a pressure of 7 or 8 lbs. per foot. As there is a great probability that there will be neither heavy rain nor hail while the maximum weight of snow rests on the roof, it may be assumed with safety that the two items of accidental pressure just defined will make sufficient provision for any other sources of accidental stress, of which, therefore, we need not take any special notice. In the following tables we give the items of permanent pressure due to the covering and to the structure of the roof itself, which, added to the items previously defined, will make up the whole weight, which must form the basis of calculation of the strength of the roof.

*Table of Weight of Covering.*

| Nature of Covering. | Weight in lbs. per square foot. |
|---|---|
| | lbs. |
| Common Tiles . . . | 13 |
| Hollow Tiles . . . . | 16 to 19 |
| Slates . . . . . | 8 |
| Rolled Copper . . . . | 3 |
| Zinc . . . . . | 2 |
| Galvanized Sheet Iron . . | 2 |
| Corrugated Sheet Iron . . | 2½ |
| Asphalte . . . . . | 5½ |

*Table of Weights of Principals and Purlins.*

| Distance of Principals. | Span. | Weight of Principal | Weight of Purlins for one bay. | Weight per square foot of roofing | OBSERVATIONS. |
|---|---|---|---|---|---|
| ft. in. | ft. in. | lbs. | lbs. | lbs. | |
| 6 6 | 26 0 | 137 | 225 | 2·03 | These data are quoted from General Morin's work; principals supposed to be trussed as per diagram No. 2; their weight in this table has been increased by the amount of one-fourth for deficiency in rafters; angle of roof about 25°. |
| 6 6 | 40 0 | 337 | 290 | 2·20 | |
| 6 6 | 65 9 | 888 | 418 | 2·87 | |
| 6 6 | 82 0 | 1668 | 482 | 3·80 | |
| 9 10 | 26 0 | 194 | 508 | 2·59 | |
| 9 10 | 40 0 | 502 | 653 | 2·76 | |
| 9 10 | 65 9 | 1387 | 943 | 3·39 | |
| 9 10 | 82 0 | 2625 | 1088 | 4·34 | |
| 13 1 | 26 0 | 245 | 959 | 3·33 | |
| 13 1 | 40 0 | 580 | 1233 | 3·26 | |
| 13 1 | 65 9 | 1705 | 1781 | 3·81 | |
| 13 1 | 82 0 | 2755 | 2055 | 4·22 | |
| Mean weight per square foot 3·22 lbs. | | | | | |
| 9 0 | 84 0 | 4480 | 1980 | 7·10 | Example No. 1 to be described. |
| 14 0 | 54 0 | 2240 | 4935 | 8·83 | " 2 " |
| 6 6 | 55 6 | 2520 | 1681 | 10·0 | " 3 " |
| 6 0 | 26 0 | 600 | 330 | 5·34 | " 4 " |
| 20 0 | 72 0 | 3936 | 6116 | 4.77 | " 5 " |
| Mean weight per square foot 7·2 lbs. | | | | | |

From this it appears that General Morin's theoretical roofs are a little less than half as heavy as those selected from actual practice; but, as we have been very careful in our selection, we are inclined to think that the theoretical roofs are considerably two light.

If, now, we sum up the pressures arising from the various sources enumerated, we shall find that the loads per square foot for different kinds of covering, are as follows :—

| Nature of Covering. | Weight in lbs. per square foot. |
|---|---|
| | lbs. |
| Common Tiles . . . . | 33 |
| Hollow Tiles . . . . . | 29 |
| Slates . . . . . | 28 |
| Rolled Copper . . . . | 23 |
| Zinc . . . . . | 22 |
| Galvanized Sheet Iron . . | 22 |
| Corrugated Sheet Iron . . | 22½ |
| Asphalte . . . . . | 27½ |

The load of 40 lbs. per square foot, which is generally taken by English engineers as a basis in the calculation of roofs, is by no means exaggerated, though it may be quite sufficient. Having thus provided our readers with all the data required for the determination of the strength of the various parts of a roof, we will now proceed to the examination and description of the examples already referred to, and point out such practical details as may be of especial interest in the study upon which we are engaged.

Example 1 is the roof over the Longton New Market, Staffordshire, and was designed by Mr. Burrell, the architect of that place. In this case the rafters are not allowed to meet at the apex of a triangle, but are connected by means of a collar some distance below that apex; the statical conditions of the trussing, however, are not changed on this account. The stresses upon the various parts of the principal are to be determined as if the rafters met at the apex, and the stress upon the collar is equal, and of contrary nature to that on the main tie, as due to the primary truss. To satisfy the minds of our readers we have appended to the drawing of the roof the diagram of stresses. The rafters here are made of two angle irons, 3 in. × 1½ in. × ¼ in., bolted back to back, having an aggregate area of 2¼ square inches, with a wooden packing between them of adequate strength almost by itself to do the work of the rafter, if it were continuous; as it is, however, it forms no element of strength, and is only here for convenience of fixing the boarding which carries the slate. The thrust upon the rafter is 7¾ tons, and the stress upon the square inch, taken into account the bending moment, is about 8 tons. The tie rod is made of flat bars, and double, for convenience of making the joints; it has an area of 1·8 square inches, deduction being made for bolt-holes, and, the maximum pull being 7 tons, sustains a stress of about 4 tons per square inch; in these respects, therefore, the roof is well proportioned. The secondary trussing, however, is defective, and as the bar instead of being a strong strut, is only a thin flat rod, the upper secondary truss can scarcely act as such, and, in consequence, a great stress is thrown upon the upper portion of the rafters. The collar supports a lantern roof, the vertical sides of which are glazed, the whole of the framing and sash-bars being made of wood. As the principals are only 6 ft. 6 in. apart, there are no purlins to the roof, but a continuous layer of 1¼ in. boarding spans from principal to principal, and carries the slates. The proportion of wood in this roof is such as to lead us to suppose that it could never have been intended to be fire-proof, and on that ground we are inclined to ask the architect why he has introduced so much iron into it, and thrown so much more expense upon the purse of the market commissioners? or else to ask this latter respectable body why they did not grant the architect funds sufficient to enable him to realize the above named most desirable object.

Example 6 is a roof and shed for the Russian Admiralty, and was, in the first instance, designed with an intended space of 10 feet between the principals. At the express desire of the Russian officials, however, this distance has been increased to 20 feet, although by so doing the weight of the whole structure has been somewhat increased also. The whole width of the space roofed over is 72 feet, but the actual span of the principal is only 52 feet, there being a space of 10 feet on each side, covered with a lean-to roof, glazed in the whole of its length, and so placed as to be continuous with the main rafter. This arrangement has been adopted in imitation of the sheds at Chatham Dockyard, for convenience of carrying a line of shafting on the

main standard. The roof is very high pitched, being at an angle of 45°, on account of the heavy falls of snow experienced in the Russian climate; a louvre roof at a smaller angle of 30° spans about ¼th the whole roof, the vertical sides of which are glazed to admit the light into the centre of the building, and in order to prevent any great accumulation of snow upon it, a small platform has been provided upon the ridge to admit of a man walking along and pushing the snow down when that is required. The whole of the shed, with the exception of the glazed portions, is covered and closed with corrugated galvanized iron, No. 20 W. G. This circumstance has enabled the constructors of the roof, without incurring any additional expense, to place the purlins immediately over the centres of resistance of the trussing, and thus the rafters are relieved from all bending stress. The thrust upon them is 25½ tons, to resist which we have an area of 4½ square inches, causing a stress of 5⅔ tons on the square inch. The main tie rods and braces are made of flat bar iron, for the sake of cheapness and expedition in the execution of the work; the lower ties are made of two bars, 3½ in. × $\frac{7}{16}$ in., and deduction being made in the area for bolt-holes, sustain a stress of 8½ tons to the square inch; the braces are made of a single bar 3¾ in. × ½ in., and sustain the same amount of stress; the raised portion of the main tie sustains only a stress of 4½ tons on the square inch, and might have been made a little lighter, but for the sake of appearance. The glass here, as in some of the previous examples, is carried by T iron sash bars, placed at distances of 12 inches, with the exception of the glazed portions of the louvre roof and of the gable end, where the sashes are made of wood. The purlins are of T iron, excepting in those places where they carry the sashes, being there made of channel iron; owing to the great span between the principals, they are trussed, but might with safety have been a little lighter.

(To be Continued.)

---

## *The Middle Level Inundation.*

From the Lond. Civ. Eng. and Arch. Jour., Jan., 1863.

The calamitous inundation of the Middle Level district a few months since, and the various means adopted to remedy the disaster, were described in this *Journal* at the time of the occurrence. The subject is, however, so important and full of interest, that the following narrative of the event, and of the means employed to repair the Middle Level Sluice, will be acceptable to our readers. It was delivered in the course of the introductory address at the commencement of the present session of the Institution of Engineers in Scotland, by Mr. William Johnstone, the president:—

The early Dutch engineers, brought over by James I. of England, divided those immense tracts into levels or confederations, each getting peculiar privileges granted them by parliament, with power to

levy rates on the acreage benefited by their main drains and outfalls, for their construction and maintenance.

The Middle Level is one of those, consisting of 140,000 acres, extending nearly to Peterborough, and cut from off the seaboard by a belt of intermediate fens 8 miles wide, under separate commissions, each maintaining, by their own taxation, independent drains and outfalls. The only thing common to all is the river Ouse, into which they all in that quarter drain, each commission subscribing to a general purse for the maintenance of its banks. This river rises in Bedfordshire, pursues a north-easterly and very tortuous course, receiving contributions from the Cam and other rivers as it passes through Cambridgeshire, and reaches the sea through the Norfolk estuary, a few miles below Lynn. It is tidal for many miles into the interior, which during floods hinders the free passage of the water to the sea, and often prevents the gates of the inland main drains being opened for several days together.

The original outfall of the Middle Level waters into this river was, on account of the intermediate fens already mentioned, placed some 15 miles from the sea, and was particularly subject to irregularity of action. The commissioners consulted the late Mr. James Walker, an engineer who was eminent for his skill in hydraulic works. Mr. Walker advised the entire removal of the outfall sluice 9 miles further down the river, and that parliamentary powers should be sought to make a main drain across the intermediate fens to it. This was accordingly done, and, after encountering a severe parliamentary contest, the act was obtained.

The sluice consisted of three 20 ft. openings, the sills being 6 ft. below low-water of spring-tide; strong pointed gates opening outwards prevented the ingress of the tide so soon as the level of the water in the river exceeded that in the drain. The drain, which is perfectly straight, is on an average 130 ft. wide; and its bottom, for the 8 miles across this district, is 7 ft. below low water. The level of the adjoining lands being only 3 ft. 6 ins. above low-water for a length of 6 out of the 8 miles, really gave good grounds for objecting to such a dangerous element being carried out on such a large scale through their very midst. But what they most dreaded was an accumulation of upland or fresh water in the drain during floods, more than could be discharged in the interval of low-water, the pressure of which on banks which, however carefully constructed originally, might by negligence in maintenance become unfit to meet all exigencies. On that ground they opposed the bill, and obtained protective clauses; but it does not seem to have occurred to them that any failure could ever take place in the outfall sluice, and it will be for the courts of law to decide whether those clauses do not altogether exclude the sufferers from any compensation whatever for the damage done by the sea. This is mentioned for two reasons—first, to point out that the land inundated was not the Middle Level at all, but the intermediate districts; and secondly, to be excused from giving, directly or otherwise, any opinion as to the sufficiency or insufficiency of the works which for eighteen

years stood well, and almost convinced the most timid opponents that their former fears were groundless. Everybody admitted the drain and outfall sluices, from their magnitude and apparent efficiency, taken as a whole, to be a masterly piece of engineering.

To the Middle Level the boon was incalculable, and far more than realized the most sanguine expectations of its immense population. Pumping engines in many districts were abandoned, and land which was worthless during the old state of drainage soon brought upwards of £50 an acre.

On the 4th May, this year, Mr. Walker's grand sluice, without much previous symptom of decay, fell in pieces, as if rent by an earthquake; and the tidal waters of the Ouse rushed with indescribable fury up to the drain, until at the end of the eight miles they were checked by the barrier sluice on the frontier of the Middle Level district. The drain for this distance became a sort of creek; and had its banks been strong enough to have resisted until a dam could have been made across the mouth, no inundation to the adjoining country would have taken place. This state of things lasted for a week, several minor breaches in the banks being successfully stopped at every tide, until at last the west bank gave way at a point situate 4 miles up, and a tide 14 feet higher than the land rushed over the devoted country, then beaming with most luxuriant crops. The land, being all of the same level, was not for a few tides covered to any depth, consequently the farmers were able to escape with their lives, and also to secure their cattle. All attempts to stop the breach were perfectly futile, owing to the rush of water back to the drain again during low water. This altered state of things had also a wonderful effect on the dam the farmers were trying to put across the mouth. The twenty-four barges, varying in size from 30 to 80 tons each, which had been loaded and sunk in the yawning chasm to form a base for some thousands sacks of clay to be built on at low water, were speedily separated and turned over; and nothing that could be sunk or thrown into the torrent would for a moment remain.

By the late Mr. Walker's recommendation, Mr. Hawkshaw visited the scene of disaster to see what could be done; and he at once gave orders to give up all attempts to stop the breach in the bank of the drain, which by this time was about 100 yards wide, because, if successful, the chances were that the opposite bank would give way, and do still greater damage to the lands on the other side. He also abandoned the idea of constructing the dam at the mouth, most of which had now been carried to sea, as, in addition to the sacks of clay and other make-shift material which were being thrown in, he wished to drive a few piles; so, taking advantage of a timber bridge of three openings across the drain near the mouth, he had all the pile engines that could be found in the neighborhood placed on it, and set to work; nothing was to be put in until the piles were driven on either side of the bridge, and strongly braced together; the planking was then to be taken up, and the prepared material dashed in. Matters were so arranged that much progress was made in the course of two days with

the driving of the piles; but during the progress of this work, up turns one of the huge 80-ton barges (which was supposed to have followed its companions out to sea), and, dashing against the row of newly driven piles, snapped them right through, and carried away the entire bridge as well as the piling engines and necessary appliances—the men only escaping with their lives. Two other occupation bridges shared a similar fate, but a bridge carrying a turnpike road resisted sufficiently to afford time to secure it. This was a most unfortunate accident, as great difficulty was experienced in getting a supply of pile engines in the neighborhood.

Now was the time for the Dutch engineer, who with Mr. Hawkshaw's consent, had been sent down to try what could be done by sinking cradles, for such was the excitement generally throughout the country, and the imminent peril of the surrounding district, that Mr. Hawkshaw, seeing the time which must necessarily elapse before the destroyed plant could be replaced, and a dam such as he deemed necessary could be constructed, felt he would not be justified in offering any opposition; but, on the contrary, he heartily supported him. In the meantime, a few tidal and other observations established some facts that set all minds at ease, and went a great way in discountenancing the Dutch mode of procedure. 1st, The land inundated extended 6 miles along the west side of the drain, and was 2 miles broad at the widest place. On an average the water was 5 feet deep over all, being luckily confined to that area and depth by the existence of two roads, which stood about 1 ft. 6 in. above that level, and surrounded it for many miles. And 2d, The tidal observations showed that the tide affected the level of the vast lake to an extent of only 6 inches; so long, therefore, as the level of the roads held good, no further damage could arise by the free admission of the tide. The Dutchman, failing in the first attempt, was preparing a second cradle, when it became a very serious question whether he would not, by pounding up a certain quantity of water every successive layer of cradles he sunk (for to stop it in a few tides was not to be hoped for) gradually, but undoubtedly, raise the level of the water from 9 ft., at which it stood, until, in the course of time, it would approach the height of 18 feet, which was the mark the same tide made at the dam. Where, then, would be the 1 ft. 6 ins. we had to come and go on? His operation was, therefore, after due deliberation, stopped.

The difference of level of the water in the fen from that in the Ouse arose from the tidal current having to pass 4 miles through the drain before entering the inundated land; and from the extent of area inundated being no less than 12 square miles, it only affected the height of the water in the fen to the extent of 6 inches, as afterwards explained.

Before giving a description of Mr. Hawkshaw's dam, I may state some of the difficulties he had to contend with—1st, The high water in the inundated fen, as compared to the same water in the Ouse, was as 9 feet to 18 feet, and the tide rose and fell in the fen 6 inches. Nothing approaching low water in the river could ever, therefore, be

obtained in the drain. The only interval of repose, or what might be called slack water, was when the tide outside attained the height of 8 ft. 6 ins., or level of the low, water in the fen. Ten minutes time was sufficient to send a gentle current inwards, which increased in velocity every minute afterwards until high-water; but the high-water in the river, being 9 feet higher than in the fen, no still water was again obtained until the tide had receded in the river to that level; it then rushed out like a mill stream until the tide rose to 8 ft. 6 ins. again. 2d, The bed of the drain being 7 feet below low-water mark, it followed that, at the time of slack-water, when any work could be done at all, the depth of water in the drain was 15 ft. 6 ins.; this was increased some 2 feet more, notwithstanding all efforts to maintain the bottom. The drain a short distance inside the site of the dam was ultimately deepened to 17 feet for a distance of 20 chains. Great caution was therefore necessary in any attempt to contract the sectional area.

The first thing to be done was to construct across the drain a strong stage 30 feet wide, resting on screw timber piling, which was projected into the current—the capstans on the piles being turned by ropes from the shore. Close piling on each side of this staging was then commenced, and continued from each shore until a clear space of 90 feet in the centre remained, it being considered imprudent to carry it further. This space was divided into twelve openings, by driving twin piles on each side of the stage opposite to each other, at 7 ft. 6 ins. intervals. Great care was necessary in pitching those piles, and it could only be done during the short time of slack-water. Each pile was 14 inches square, and separated from its fellow by the first one having a thin piece fixed to its outer face, against which the second was driven, thus forming two grooves, 8½ inches wide, for the panels, which were intended to be dropped into the openings, to slide in. Strong waling pieces of whole timber inside and out of each row at top, and as low as the water would admit of at the bottom, kept the whole in gauge, and the transverse timbers and iron bracings communicated any outward pressure through the dam from one row to the other, the outside of the dam being stayed to the side of the drain by double timbers, 60 feet long, the ends abutting against piles backed by a mass of concrete. These struts were placed against the waling pieces at top and bottom, and stiffened by cross diagonals like a girder. The staging was left open at the top, to admit of material being tipped from the two lines of way, laid across the dam; and communicating with the prepared heaps of puddle and other material at convenient places up and down the drain on both sides. Two outside stages, one on either side of the dam, and supported by cantilevers from the twin piles, admitted of almost any quantity of tipping from barrows to make good any scour which the soundings taken at every slack might indicate. The rush of water through the dam thus far completed was, both on the flood and ebb tide, truly alarming; the simple introduction of those piles and bottom walings causing a difference of head level of nearly 5 feet. In the midst of this roaring cataract,

this framework and the dam stood without the slighest vibration being felt.

The greatest and most anxious care was now necessary to preserve the bottom of the drain from the scouring action of such a weight of water passing over it at the rate of 10 feet a second. Tons of broken stone were tipped from the outer stages and thrown overboard from barges, to form aprons on either side. But, except as a last resource, no stone was to be thrown into the centre of the dam, lest it should prevent it afterwards from being made perfectly water-tight. The long panels composed of timber 8 inches thick, not framed, but merely built one above the other, and held together by three long bolts and heavy iron straps, made them quite rigid, and no difficulty was experienced in driving them. They were made with a sharp edge, and dollied down until their top was level with the bottom of the drain or nearly so, and backed well outside with stone. Great quantities of puddle were tipped into the dam at every slack-water; not with any hope of its remaining, but simply to feed the cancer—if I may so express it—and thereby allow less time for the dreadful current to act on the bottom. This was all the more necessary, for the piles on an average could only be driven 14 feet into the ground. All attempts to exceed that depth resulted in fracture. No doubt a bed of gravel existed at that depth totally different in character from the coarse silt and alluvial deposit resting on it, and now so anxiously maintained.

The first attempt at closing the dam resulted in failure from the fracture of two of the twin or gauge piles, which doubtless were injured in the vain attempt to get them deeper into the bottom. No blowing however, occurred, and the panels when liberated were carried off. The greatest apprehension existed until the return of slack-water, when the divers reported no damage, the lower panel driven into the ground, preventing any cutting of the bottom. In consequence of the failure all the other panels down to low-water were drawn, to allow free access to the tide, until the piles could be replaced. This was accordingly done, and a week elapsed in making good the damage and otherwise preparing to meet other contingencies, of which experience was daily pointing out the possibility. All was now ready; the panels were again swung in the gallows frames, ready to be dropped at slack water on the ebb. They were all lowered into their places in twenty minutes, material was then tipped in with great rapidity by the wagons, and the outsides weighted from the barrow stages. All was most successful; a little blowing took place where the stumps of the fractured piles interfered with the proper fitting of the panels in those places. However, by throwing a large quantity of hay, and piling a great quantity of clay bags on each side, it was checked until sufficient puddle was tipped into the centre. This was accomplished in twenty-four hours, and set so completely that not a drop escaped through. The tides no more went up the drain, but ebbed and flowed outside with a stillness which, when compared with the previous day, partook of that oppressive character experienced near a mill, or in the midst of going machinery, suddenly stopped. Syphons 3 ft. 6 ins. in diame-

ter were then placed over the dam to relieve the Middle Level from the surplus water that would not find its way to the Ouse through the old outfall, which for the present was again resorted to. Many thought they would not act. No good reason, however, could be urged against them, and all admitted that it was proper to make the experiment. These syphons have been finished and recently opened, and all found to do their work very well indeed. Their bottom level where they pass over the dam is 18 feet above low-water, and the bottom of the mouths 6 feet under low-water. In spring tides high-water rises 20 feet. These operations have succeeded in relieving the Middle Level of water, and it will be a great boon to the whole of that district.

## MECHANICS, PHYSICS, AND CHEMISTRY.

### *Webster's Process for Making Oxygen Gas.*

From the London Chemical News, No. 156.

The following report has been made by Dugald Campbell, Esq., F. C. S., to Messrs. John H. Porter and Co., the proprietors of the patent:—

As requested by you, I have made experiments in order to examine into, and report upon, the process of Mr. James Webster, of Birmingham, for "manufacturing oxygen gas, and obtaining certain other products," described in the specification of his patent, dated October 19, 1861.

The materials which I employed in my experiments were commercial nitrate of soda of the ordinary quality, and a common oxide of zinc; the first of value, I should say, at from £13 to £14 per ton, and the latter at from 30s. to 40s. per ton.

The mode of operating was as follows:—10 lbs. of the nitrate of soda and 20 lbs. of the oxide of zinc, both previously dried, were mixed roughly together, and thrown into a red-hot retort. In a minute or two, when the oxygen gas began to come off, which was ascertained by the gas having the power of supporting combustion, the gas was made to pass into what was named the purifier, which I shall afterwards describe, and from thence into a graduated gasometer.

When the gas had ceased to come off, the gasometer was shut off from the rest of the apparatus, and the contents of the retort emptied into a tray, and mixed roughly with an additional 10 lbs. of dry nitrate of soda, were returned into the retort, and distilled as before, and when no more gas was evolved, the gasometer was again shut off, and the contents of the retort discharged into a tray, and again mixed in a similar manner with 10 lbs. of the dry nitrate, and distilled as before.

The material in the retort has now become, to some degree, pasty, and is considered no longer fit to have more nitrate of soda added to it, and, from the original weight of 50 lbs., it is now reduced to 37 lbs., or has lost 13 lbs. It consists as follows:

In 100 parts.

| | |
|---|---|
| Sand with oxide of iron - - - - - | 13·66 |
| Oxide of zinc - - - - - - | 30·20 |
| Anhydrous soda - - - - - - | 24·80 |
| Nitrate of soda with a little nitrate - - - | 31·34 |

It will be seen from the above that this material contains 24·8 per cent. of anhydrous soda, which is equal to 32 per cent. of hydrate of soda, and, by boiling it in water, this hydrate of soda, together with the nitrate of soda, are dissolved out from the oxide of zinc, and may be readily separated from each other by crystallizing out the nitrate, leaving the hydrate.

But it sometimes happens that from too great a heat being employed in obtaining the gas, or from the nature of the iron of the retort used, that, besides these salts of soda, a salt of iron and soda is formed, namely, the ferrate of soda. This salt is green, and is not separated by crystallization from the hydrate, and consequently would much contaminate it, and render it much less valuable. In my opinion, it is quite easy to avoid such an action taking place.

But in the event of such an action having taken place, the use to which the residual material may be afterwards put to in the process, namely, in the purifying of the gas as it passes through the purifier, alters it, and converts it into a substance more readily to be dealt with.

The purifier, spoken of before, consists of a deep jar, at the bottom of which 5½ lbs. of water are placed; the gas from the retort is made to enter just above the water, and passes up through perforated trays, on which are spread the 37 lbs. of residual material from the retort, broken into a rough powder, and moistened with 6 lbs. of water, making together 43 lbs.

In all my experiments the residual material remained in the purifier during the distillation of the 50 lbs. of the material only, when it was removed and weighed.

The water at the bottom of the receiver is now strongly acid, with a mixture of nitrous and nitric acids, and has increased in weight in my experiments from 2 lbs. to 3½ lbs., depending upon the degree of heat used in the process. That being the case, its specific gravity is variable, and in the course of one distillation of 50 lbs., the acid water is not of much value; but it might remain in the purifier during several charges, when it would become strong and of real value, or it might be drawn off, and added to the dry residual material removed from the trays after it has done purifying the gas.

This residual material upon the perforated trays in the purifier, after the passing of the gas from 50 lbs. weight of the materials, has increased in weight in my experiments from 2 lbs. to 3 lbs., according to the temperature at which the materials are distilled, and also according to the nature of the residual material employed in the purifier, and it is now much changed, and the hydrate of soda is now almost

totally converted into nitrate of soda, and any ferrate of soda is decomposed. Its composition is as follows:—

| | In 100 parts. |
|---|---|
| Water and sand | 26·27 |
| Carbonate of soda | 5·00 |
| Oxide of iron | 6·00 |
| Oxide of zinc | 22·82 |
| Nitrate of soda with a very little nitrite | 39·91 |

The way which I would suggest of dealing with the above substance, is to add the acid water from the bottom of the purifier to it, so as to neutralize any carbonate of soda which it may contain, and boil it with water, which will dissolve the nitrate of soda from the insoluble oxide of zinc, and the solution of nitrate is afterwards evaporated for the nitrate.

The yield of gas from 20 lbs. of oxide of zinc and 30 lbs. of nitrate of soda, in my experiments, was very close, varying only from 157·85 to 159·03 cubic feet, and the time occupied in each working of 50 lbs. was, as near as may be, 9½ hours.

I was unable to fix exactly what the consumption of fuel was for one charge, but, from the data I obtained, I should say it was under 9d.

On analyzing the gas I was surprised to find that it contained a considerable per centage of nitrogen, in my experiments varying from 26·50 to 32·80 per cent.; for, independently of its supporting combustion very well, and increasing the illuminating power of coal gas to a great degree, I should not have expected nitrogen to be eliminated from the materials used, by the heat which was employed. However, finding the nitrogen there, it appears to me that it must have got there by using too high temperatures,* and I think, by experimenting at different temperatures, you may find out one where little, if any, will be produced, or one, at any rate, at which much less will be produced.

* Acting upon these suggestions, the proprietors have obtained a higher degree of purity in the gas which they find to be improved also by the addition of more water to the materials in the purifier.

---

## *Proceedings of the Manchester Association for the Prevention of Steam Boiler Explosions.*

From the Journal of the Society of Arts, No. 512.

At the last ordinary monthly meeting of the executive committee, held September 2d, 1862, Mr. L. E. Fletcher, chief engineer, presented his monthly report, of which the following is an abstract:—

During the past month the ordinary visits of inspection have been made, and 8 boilers tested by hydraulic pressure, the following defects being discovered in the boilers examined:—Fracture, 3 (2 dangerous); corrosion, 26 (6 dangerous); safety-valves out of order, 14; water gauges ditto, 10; pressure gauges ditto, 13; feed apparatus, ditto, 4; blow-off cocks ditto, 37 (1 dangerous); fusible plugs ditto, 6; furnaces out of shape, 3; blistered plates, 2. Total, 118 (9 dangerous). Boilers

without glass water gauges, 4; without pressure gauges, 16; without blow-off cocks, 11; without back pressure valves, 31.

The principal cases of dangerous injury which have arisen this month have been due to corrosion, the continued recurrence of which shows the importance of having all boilers examined, not "externally" only, but also "internally and thoroughly."

Another explosion has occurred during the last month to the class of plain cylindrical egg-ended boilers, fired externally. The boiler in question, which was under the inspection of this Association, was one of a series of six connected together, in the midst of which it had worked, being the fourth from one end, and the third from the other. Its length was 30 feet, its diameter 5 feet, the thickness of its plates $\frac{3}{8}$ths of an inch, and its working pressure 50 lbs. The rent, as is usual in these cases, occurred at one of the transverse seams over the fire, but the development of the line fracture was somewhat peculiar. In ordinary cases these boilers, on explosion, separate at one of the ring seams into two distinct halves, which fly in opposite directions; but, in the present instance, the first belt of plates was completely severed from the remainder of the boiler and flattened out, having rent through the line of rivets at each of its four edges, while the egg-end had become entirely disengaged from it, and, in addition, was torn into two parts. The remainder of the boiler, which was by far the greater portion, being about twenty-four feet long, had flown to a distance of about eighty to ninety yards, and the chimney, which was reduced to a heap of ruins, had either been swept down by it in its course, or blown down by the impact of the steam.

There was no evidence of there having been either deficiency of water or excess of pressure; while each boiler in the series was fitted with two lever safety-valves of three inches diameter, a glass water gauge, and a back-pressure feed valve. The exploded boiler was about four years old, and had been repaired seven months since, at the part immediately over the furnace, by the introduction of two new plates.

It will be observed that the above explosion is another instance of the liability of these externally-fired boilers to rend at the transverse seams over the fire. The combined duty thrown upon these seams is so great, that there is more uncertainty with these boilers than with those of the more internally-fired double-furnace class in ordinary use in Lancashire. All the points in the latter can be so entirely mastered that they may be thoroughly relied on, and if well made, and in sound condition, can, with proper care in working, be guaranteed as safe for a period of twelve months from the time of examination. Not so, however, with the externally-fired boiler, in which the shell has to endure the entire disruptive strain combined with the direct impingement of the flame. In the internally-fired boiler these two duties are divided; the shell, which bears the tensile strain, being guarded from the intense action of the fire, which the furnace tubes are adapted to bear, from their small diameter and facility for strengthening, either by flanched seams, hoops, or otherwise; while the deposit, which to a great extent rolls off the furnace crowns, and falls

harmlessly to the boiler in one case, deposits itself immediately over the fire in the other. Thus the seam of rivets in externally-fired boilers have to contend with the combined influence of tensile strain, the direct action of the fire, and too frequently with an accumulation of incrustation tending to overheating, and even where this does not form a positive coat, it may yet suffice so to thicken the water that the steam lifts it from the surface of the plate, when over-heating unavoidably ensues; added to which, sudden drafts of cold air, on opening the furnace doors, cool the outer laps of the plate at the seams, which thus become subjected to the constant alternations of expansion and contraction.

Under these circumstances it is not surprising that the seams of rivets in under-fired boilers should frequently be found suddenly to give way, for which the surest remedy will prove to be the substitution of internally-fired boilers in their place. Where, however, those externally-fired are still adopted, it is earnestly recommended, in the first place, that good materials and workmanship should be secured; in the second, that every means should be adopted for the prevention of incrustation; and, in the third, that the seams of rivets should be constantly and narrowly watched, so as to detect the first signs of weakness, which should be immediately repaired.

Ready examination is facilitated by setting these boilers, as some of our members are doing, with a single direct flash flue, in which are a series of bridges, one behind the other, for keeping the flame in contact with the boiler; an entrance being made beneath the furnace bars, as well as a small archway through the back bridges, to allow of a communication throughout.

---

For the Journal of the Franklin Institute.

*Rules for selecting the Exponents in Nystrom's Parabolic Construction of Ships, and approximating the Dimensions of a Vessel when its purpose is given.* By JOHN W. NYSTROM, C. E.

(Continued from page 107.)

From the preceding formulas, 7 and 9, we have

$$\text{D} = \left(\frac{n'\ 2n''}{(n'+1)(2n''+3n''+1)}\right) \text{L B } d,$$

in which the factor in the parenthesis is the co-efficient for the length, breadth, and draft of water of the vessel. Let us call this co-efficient $= n$, we have $\text{D} = \text{N L B } d$. In the accompanying Table IV., N is calculated for different exponents $n'$ and $n''$, as indicated in the columns. The draft of water in the column $d$, means the draft in proportion to the size of the vessel; when the draft is half the beam, it is considered great, and if only $\frac{1}{8}$th or $\frac{1}{16}$th of B, it is small. The purpose of the vessel is noted under the Table. Suppose it is required to build a steamer of light draft for the purpose of carrying freight and passengers, we find in the Table that the exponent for the displacement should be about $n'' = 4$, and that for the cross-section $\mathcal{M}$ about $n' = 8$, when the co-efficient $\text{N} = 0{\cdot}632$, and the displacement $\text{D} = 0{\cdot}632\ \text{L B } d$.

Let us assume certain proportions of the length L, beam B, and draft $d$; the displacement given in tons T, we have

$$T = \frac{N L B d}{35}, \text{ or } T = L\left(\frac{N B d}{35}\right)$$

in which the factor in the parenthesis is a co-efficient for L, and may be a function L, so that $T = \frac{L^3}{O^3}$ and $L = O\sqrt[3]{T}$. The factor O is calculated in the Table V. for different proportions of L, B, and $d$, as required for the different purposes and conditions. Suppose the size of a vessel is given in T = 1200 tons of displacement, to be constructed for freight with moderate speed, and for navigating very shallow water. Required the exponents $n'$, $n''$, and the dimensions, length L, beam B, and draft of water $d$? From Table IV. we may select $n' = 10$ and $n'' = 6$ when N = 0·720; find the nearest number to this in column N, Table V., which is N = 0·743; continuing this line to the three columns, of river steamers of light draft, we may select the co-efficient O = 36·8, when the length of the vessel will be $L = 36{\cdot}8\sqrt[3]{1200} = 391{\cdot}1$ feet. Divide this length by the number of the column 82, or

391·1 : 82 = 4·77 feet, the draft of water, and the beam

$$B = \frac{35\,T}{N L d} = \frac{35 \times 1200}{0{\cdot}743 \times 391{\cdot}1 \times 4{\cdot}77} = 30{\cdot}3 \text{ feet.}$$

TABLE IV.—*To Approximate Size and Shape of Vessels.*

| $d$ | $\frac{M}{n'}$ | Exponents for Displacement $n''$. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 | 2·5 | 3 | 3·5 | 4 | 5 | 6 | 8 | 10 |
| Draft of Water. Deep. | 2 | ·356 | ·397 | ·429 | ·453 | ·494 | ·500 | ·528 | ·558 | ·577 |
| | 2·5 | ·381 | ·425 | ·459 | ·486 | ·508 | ·541 | ·566 | ·597 | ·620 |
| Middling. | 3 | ·400 | ·447 | ·482 | ·510 | ·533 | ·563 | ·594 | ·627 | ·650 |
| | 3·5 | ·414 | ·462 | ·500 | ·528 | ·552 | ·589 | ·615 | ·650 | ·673 |
| | 4 | ·427 | ·476 | ·514 | ·544 | ·569 | ·606 | ·633 | ·668 | ·693 |
| | 5 | ·444 | ·496 | ·535 | ·567 | ·592 | ·631 | ·660 | ·696 | ·722 |
| Light. | 6 | ·458 | ·509 | ·550 | ·583 | ·610 | ·649 | ·679 | ·717 | ·742 |
| | 8 | ·474 | ·529 | ·571 | ·605 | ·632 | ·673 | ·704 | ·743 | ·770 |
| | 10 | ·490 | ·547 | ·590 | ·625 | ·654 | ·696 | ·720 | ·759 | ·797 |
| Purpose. | | Speed and Passengers. | | | Freight and Passengers. | | | Freight and Slow Speed. | | |

TABLE V.—*Length of Vessels = Tabular number* $O\sqrt[3]{T}$.

| | $n'$ & $n''$ | Proportion of Draft and Length of Vessels. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | 8 | 12 | 18 | 26 | 36 | 48 | 64 | 82 | 102 |
| Heavy Ordinary Sailing Freight. Vessels. Yachts. | ·356 | 14·9 | 19 0 | 23·7 | 28·9 | 34·0 | 38·9 | 43·6 | 47·2 | 48·0 |
| | ·425 | 13·9 | 17·7 | 22·1 | 26·9 | 31·7 | 36·2 | 40·6 | 43 9 | 44·5 |
| | ·482 | 13·3 | 17·0 | 21·2 | 25·8 | 30·3 | 34·7 | 38·9 | 42·1 | 42·7 |
| | ·528 | 12·9 | 16·5 | 20·5 | 25·0 | 29·4 | 33·7 | 37·7 | 40 8 | 41·3 |
| | ·569 | 12·5 | 16·0 | 20·0 | 24·4 | 28·7 | 30·8 | 36·8 | 39·8 | 40·3 |
| | ·631 | 12·1 | 15·5 | 19·4 | 23 5 | 27·6 | 31·6 | 35·4 | 38·3 | 38·8 |
| | ·679 | 11·8 | 15·1 | 18·8 | 22 9 | 26·9 | 30·8 | 34·6 | 37·4 | 38·0 |
| | ·743 | 11·6 | 14·8 | 18·5 | 22·5 | 26·5 | 30·3 | 34 0 | 36·8 | 37·2 |
| | ·797 | 11·2 | 14·3 | 17·9 | 21·8 | 25.6 | 29 3 | 32·9 | 35·6 | 36·0 |
| Conditions. | | Vessels for Deep Water. | | | Ordinary Navigation. | | | River Steamers, Light Draft. | | |

Should a greater beam be required, select o in the column 102 when the draft of water will be less.

For light draft and speed, the exponents should be selected towards the corner ·490, Table IV.; and for freight and light draft towards the corner ·797. For heavy freight and light draft, the proportions of the vessel should be selected towards the corner 36·0, Table V.; sailing yachts for deep water towards the corner 14·9, and ordinary vessels for deep water in the middle of column 12.

The following Tables VI. and VII. are calculated for twenty parabolic exponents.

TABLE VI.

| Exponent $n$ or $n'$. | Sub-ordinates for the Water-line ▬ or Cross-section $\mathcal{N}$. $b = 1$. | | | | | | | $\blacksquare = B L \times \mathcal{N} = B d$ | $k$. |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| 2· | ·2345 | ·4375 | ·6094 | ·7500 | ·8593 | ·9375 | ·9844 | ·6666 | 1·94 |
| 2·25 | ·2595 | ·4766 | ·6527 | ·7897 | ·8899 | ·9558 | ·9834 | ·6923 | 1·98 |
| 2·5 | ·2838 | ·5129 | ·6912 | ·8232 | ·9139 | ·9687 | ·9944 | ·7142 | 2·00 |
| 2·75 | ·3073 | ·5466 | ·7254 | ·8513 | ·9326 | ·9779 | ·9967 | ·7333 | 1·98 |
| 3· | ·3301 | ·5781 | ·7558 | ·8750 | ·9472 | ·9844 | ·9980 | ·7500 | 1·94 |
| 3·25 | ·3521 | ·6074 | ·7829 | ·8944 | ·9587 | ·9889 | ·9988 | ·7647 | 1·91 |
| 3·5 | ·3733 | ·6346 | ·8070 | ·9116 | ·9677 | ·9922 | ·9993 | ·7777 | 1·88 |
| 3·75 | ·3939 | ·6600 | ·8284 | ·9256 | ·9747 | ·9944 | ·9995 | ·7894 | 1·85 |
| 4· | ·4138 | ·6836 | ·8474 | ·9375 | ·9802 | ·9961 | ·9997 | ·8000 | 1·82 |
| 4·5 | ·4517 | ·7260 | ·8794 | ·9557 | ·9878 | ·9978 | ·9998 | .8181 | 1·76 |
| 5· | ·4871 | ·7627 | ·9046 | ·9687 | ·9926 | ·9990 | ·9999 | ·8333 | 1·70 |
| 5·5 | ·5202 | ·7945 | ·9246 | ·9779 | ·9954 | ·9994 | ·9999 | ·8461 | 1·64 |
| 6· | ·5512 | ·8220 | ·9404 | .9843 | ·9972 | ·9997 | 1·000 | ·8571 | 1·58 |
| 6·5 | ·5802 | ·8459 | ·9528 | ·9889 | ·9983 | ·9998 | 1·000 | ·8666 | 1·52 |
| 7· | ·6073 | ·8665 | ·9627 | ·9922 | ·9989 | ·9998 | 1·000 | ·8750 | 1·46 |
| 8· | ·6564 | ·8989 | ·9767 | ·9960 | ·9996 | ·9999 | 1·000 | ·8888 | 1·34 |
| 9· | ·6993 | ·9249 | ·9854 | ·9985 | ·9998 | ·9999 | 1·000 | ·9000 | 1·28 |
| 10· | ·7369 | ·9437 | ·9909 | ·9990 | ·9999 | 1·000 | 1·000 | ·9090 | 1·18 |
| 12· | ·7963 | ·9683 | ·9976 | ·9998 | 1·000 | 1·000 | 1·000 | ·9231 | 1·08 |
| 16. | ·8819 | ·9991 | ·9999 | 1.000 | 1.000 | 1·000 | 1·000 | ·9412 | 1·00 |

TABLE VII.

| Exponent $n''$ | Ordinate Cross-sections $\mathcal{N}$. for Displacement $\mathcal{N} = 1$. | | | | | | | Displacement. | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | $D = \mathcal{N} L \times$ | $T = \mathcal{N} L \times$ |
| 2· | ·0545 | ·1914 | ·3713 | ·5625 | ·7384 | ·8909 | ·9688 | ·5333 | ·0152 |
| 2·25 | ·0673 | ·1795 | ·4260 | ·6236 | ·7919 | ·9135 | ·9671 | ·5663 | ·0162 |
| 2·5 | ·0805 | ·2512 | ·4772 | ·6777 | ·8352 | ·9383 | ·9889 | ·5952 | ·0170 |
| 2·75 | ·0944 | ·2987 | ·5262 | ·7247 | ·8697 | ·9563 | ·9934 | ·6204 | ·0177 |
| 3· | ·1090 | ·3342 | ·5713 | ·7667 | ·8972 | 9691 | ·9960 | ·6429 | ·0184 |
| 3·25 | ·1239 | ·3689 | ·6129 | ·7999 | ·9191 | ·9779 | ·9976 | ·6629 | ·0189 |
| 3·5 | ·1394 | ·4027 | ·6512 | ·8310 | ·9365 | ·9845 | ·9986 | ·6806 | ·0194 |
| 3·75 | ·1551 | ·4356 | ·6862 | ·8567 | ·9500 | ·9888 | ·9990 | ·6968 | ·0199 |
| 4· | ·1712 | ·4673 | ·7181 | ·8789 | ·9608 | ·9922 | ·9994 | ·7111 | ·0203 |
| 4·5 | ·2039 | ·5270 | ·7736 | ·9146 | ·9751 | ·9956 | ·9996 | ·7364 | ·0211 |
| 5· | ·2373 | ·5817 | ·8183 | ·9384 | ·9853 | ·9980 | ·9998 | ·7575 | ·0216 |
| 5·5 | ·2706 | ·6312 | ·8548 | ·9563 | ·9908 | ·9988 | ·9998 | ·7755 | ·0221 |
| 6· | ·3038 | ·6757 | ·8844 | ·9688 | ·9944 | ·9995 | ·9999 | ·7924 | ·0227 |
| 6·5 | ·3366 | ·7155 | ·9078 | ·9780 | ·9966 | ·9996 | ·9999 | ·8047 | ·0230 |
| 7· | ·3688 | ·5762 | ·9268 | ·9845 | ·9978 | ·9996 | ·9999 | ·8170 | ·0233 |
| 8· | .4309 | ·8080 | ·9540 | ·9920 | ·9992 | ·9998 | 1·000 | ·8366 | ·0239 |
| 9· | ·4890 | ·8554 | ·9710 | ·9970 | ·9996 | ·9998 | 1·000 | ·8521 | ·0244 |
| 10· | ·5430 | ·8906 | ·9819 | ·9980 | ·9998 | ·9999 | 1·000 | ·8656 | ·0247 |
| 12· | ·6341 | ·9375 | ·9934 | ·9996 | ·9999 | ·9999 | 1·000 | ·8861 | ·0253 |
| 16. | ·7777 | ·9991 | ·9998 | ·9999 | ·9999 | 1·000 | 1·000 | ·9126 | ·0261 |

In this article it is intended to show the process by which some of the formulas are obtained. The whole system is based on the simple parabolic formulas $y=\sqrt[n]{px}$, $x=\frac{y^n}{p}$, $p=\frac{y^n}{x}$, and $n=\frac{\log.p+\log.x}{\log.y}$ in which the parameter $p$ is the gauge for the parabolas. In order to apply the formulas as direct as possible to the subject in question, it is best to make a gauge that will be ready at hand, by limiting the parabolas within the size of the vessel, when the limit $x=b$, and $y=l$; see fig. 1, Plate I.

$$p=\frac{y^n}{x}=\frac{l^n}{b}, \qquad y=l\sqrt[n]{\frac{x}{b}} \qquad \text{and } x=\frac{b\,y^n}{l^n},$$

in which the length and breadth of the vessel is the gauge for the parabolas.

Let us first find the formula 5, page 99, for the area of the load water-line.

We are now obliged to refer to the calculus, from which we know that the increment of the area of any plan figure bounded by a curved line and rectangular co-ordinates, is equal to the increment of the abscissa multiplied by the ordinate; which two latter are obtained from the formula of the curve.

$$x=\frac{b\,y^n}{l^n}$$

$$\text{Differential } dx=\frac{n\,b\,y^{n-1}\,dy}{l^n},$$

multiplying this by the ordinate $y$, we obtain the differential of the area $\mathbf{a}$,

$$d\mathbf{a}=y\,dx=\frac{n\,b\,y^n\,dy}{l^n},$$

of which the integral is the area $\mathbf{a}$.

$$\int d\mathbf{a}=\mathbf{a}=\int\frac{n\,b\,y^n\,dy}{l^n}=\frac{n\,b}{l^n}\int y^n\,dy,$$

$$\mathbf{a}=\frac{nb}{l^n}\cdot\frac{y^{n+1}}{n+1},$$

but when we limit the area to the length $y=l$, we have

$$\mathbf{a}=\frac{nb}{l^n}\cdot\frac{l^{n+1}}{n+1}=\frac{n\,b\,l}{n+1},$$

which gives one-quarter of the area of the water-line, but by taking the whole beam B and length L, the whole area will be

$$\mathbf{a}=\frac{n\,\mathrm{B\,L}}{n+1}.$$

The process is precisely the same for finding the formula 7, for the cross-section $\mathfrak{M}$, where $d$ is inserted for $l$.

Let us now find the formula 9, for the displacement.

The least possible resistance to a vessel of a given displacement bounded within the given length, breadth, and depth, is when the square root of the cross-sections $\mathfrak{w}$ are ordinates in a parabola of the exponent $n''$; in this case the ordinates are taken at right angle to the centre line, and the abscissa from $\mathfrak{X}$, or the ordinates should be $\surd\overline{\mathfrak{w}} = b - x$, in which it should be clearly understood that the exponent for the parabola of the water-line $n$ need not be the same as $n''$ for the ordinate cross-sections $\mathfrak{w}$, but for simplicity of notation the two dots will be omitted in the following formulas, where $n$ means $n''$.

From the calculus of cubature we know that any solid bounded by an irregular surface, its increment of solidity is equal to the increment of the abscissa, multiplied by the area of the ordinate cross-section. In this case $y$ will be the abscissa.

$$\textit{Formula 4.} \quad \mathfrak{V} = \mathfrak{X}\left(1 - \frac{x}{b}\right)^2$$

From the formula of a parabola we have

$$\text{Differential } dx = \frac{n\,b\,y^{n-1}\,dy}{l^n},$$

$$\text{and } dy = \frac{dx\,l^n}{n\,b\,y^{n-1}},$$

and for the displacement D we have

$$\text{Differential } d\mathrm{D} = dy\,\mathfrak{w} = \frac{\mathfrak{X}\,l^n\left(1 - \frac{x}{b}\right)^2 dx}{n\,b\,y^{n-1}}.$$

By integrating we have

$$\text{Displacement } \int d\mathrm{D} = \int \frac{\mathfrak{X}\,l^n\left(1 - \frac{x}{b}\right)^2 dx}{n\,b\,y^{n-1}},$$

$$\text{but } y = l\sqrt[n]{\frac{x}{b}} = \frac{l\,x^{\frac{1}{n}}}{b^{\frac{1}{n}}} \text{ and } y^{n-1} = \frac{l^{n-1}\,x^{1-\frac{1}{n}}}{b^{1-\frac{1}{n}}},$$

this value of $y^{n-1}$ inserted in the denominator of the integral, will be

$$\mathrm{D} = \int \frac{\mathfrak{X}\,l^n\,b^{1-\frac{1}{n}}\left(1 - \frac{x}{b}\right)^2 dx}{n\,b\,l^{n-1}\,x^{1-\frac{1}{n}}} = \int \frac{\mathfrak{X}\,l\left(1 - \frac{x}{b}\right)^2 dx}{n\,b^{\frac{1}{n}}\,x^{1-\frac{1}{n}}},$$

$$\text{of which } \mathrm{D} = \frac{\mathfrak{X}\,l}{n\,b^{\frac{1}{n}}} \int \frac{\left(1 - \frac{x}{b}\right)^2 dx}{x^{1-\frac{1}{n}}}, \quad \ldots \quad a$$

$$\left(1 - \frac{x}{b}\right)^2 = 1 - \frac{2x}{b} + \frac{x^2}{b^2}, \text{ and}$$

$$\int \frac{\left(1 - \frac{x}{b}\right)^2 dx}{x^{1-\frac{1}{n}}} = \int \left(\frac{dx}{x^{1-\frac{1}{n}}} - \frac{2x\,dx}{b x^{1-\frac{1}{n}}} + \frac{x^2 dx}{b^2\,x^{1-\frac{1}{n}}}\right).$$

$$\int \frac{dx}{x^{1-\frac{1}{n}}} = \int x^{\frac{1}{n}-1}\,dx = nx^{\frac{1}{n}},$$

$$\int -\frac{2x\,dx}{bx^{1-\frac{1}{n}}} = \int -\frac{2x^{\frac{1}{n}}\,dx}{b} = -\frac{2x^{1+\frac{1}{n}}}{b\,(1+\frac{1}{n})},$$

$$\int \frac{x^2\,dx}{b^2\,x^{1-\frac{1}{n}}} = \int \frac{x^{1+\frac{1}{n}}\,dx}{b^2} = \frac{x^{2\ +\frac{1}{n}}}{b^2(2+\frac{1}{n})},$$

By inserting these integrals in the formula *a*, we have the displacement

$$\text{D} = \frac{\mathfrak{M}\,l}{n\,b^{1-\frac{1}{n}}}\left(\ n\,x^{\frac{1}{n}} - \frac{2x^{1+\frac{1}{n}}}{b(1+\frac{1}{n})} + \frac{x^{2}+^{\frac{1}{n}}}{b^2(2+\frac{1}{n})}\right).$$

It is required to find a formula expressing the whole displacement from $\mathfrak{M}$ to the stern or stem of the vessel, for which we can in the preceding formula make $x = b$, when

$$\text{D} = \frac{\mathfrak{M}\,l}{n\,b^{\frac{1}{n}}}\left(\ n\,b^{\frac{1}{n}} - \frac{2\,b^{1+\frac{1}{n}}}{b\,(1+\frac{1}{n})} + \frac{b^{2+\frac{1}{n}}}{b^2\,(2+\frac{1}{n})}\right),$$

$$\text{D} = \frac{\mathfrak{M}\,l}{n\,b^{\frac{1}{n}}}\left(n\,b^{\frac{1}{n}} - \frac{2\,b^{\frac{1}{n}}}{1+\frac{1}{n}} + \frac{b^{\frac{1}{n}}}{2+\frac{1}{n}}\right).$$

Rejecting the factor $b^{\frac{1}{n}}$, we have

$$\text{D} = \frac{\mathfrak{M}\,l}{n}\left(n - \frac{2}{1+\frac{1}{n}} + \frac{1}{2+\frac{1}{n}}\right).$$

The factor in the parenthesis will be

$$\frac{2\,n^2}{2\,n^2+3\,n+1},$$

and we arrive to the final formula for the displacement, when taking the whole length L, and resuming the dots on the exponent $n''$,

$$\text{D} = \mathfrak{M}\,\text{L}\,\frac{2\,n^{2''}}{2\,n^{2''}+3\,n''+1}.$$

This is the formula as it appears in "Nystrom's Treatise on Ship Building and Marine Engineering," which gives the same result as that in this *Journal*, page 99, or

*Formula* 9. $$\text{D} = \frac{n''\,\mathfrak{M}\,\text{L}}{(n''+1)(1+\frac{1}{2n''})}.$$

Such an operation is necessary for many formulas, which are apparently very simple when finished; the formulas, 11, 12, 13, and others, required each a more extensive operation, which shall be left for the reader to work out.

For the Journal of the Franklin Institute.

## *Problems on Beams.*

By D. Wood, M.A., Prof. Civil Eng., University of Michigan.

I find in *Weisbach's Mechanics and Engineering*, vol. i. p. 208, that when a beam is loaded over part of its length, the maximum moment—and hence the *dangerous section*—is *assumed* to be at the centre of the load. I find by investigation that this assumption is not correct.

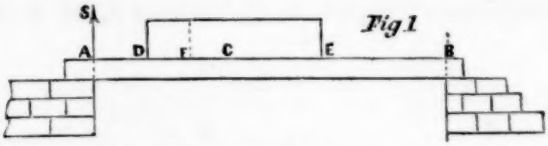



*Fig 1*

Let $l$ = AB = the length of the beam.

$2a$ = DE = length of the load, which is uniformly distributed over DE.

C be the centre of the load.

$l_1$ = AC $\qquad$ $l_2$ = CB.

$w$ = the load on a unit of length, say 1 inch.

$x$ = AF = the distance to any section.

S = the re-action of the support.

Then

$$\text{AD} = l_1 - a \qquad \text{DF} = x - \text{AD} = x - l_1 + a.$$

Load on $\text{DF} = w(x - l_1 + a)$.

" $\text{DE} = 2wa$.

By the principle of moments we have

$$Sl = 2wa.l_2 \quad \therefore \quad S = 2wa\frac{l_2}{l}.$$

Observing that the lever arm of the load on DF is $\frac{1}{2}$ DF, we find that the moment of strain on the section at F is

$$Sx - \frac{w}{2}(x - l_1 + a)^2,$$

$$\text{or,} \quad \frac{2wal_2}{l}x - \frac{w}{2}(x - l_1 + a)^2 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

which we wish to make a maximum. Differentiate and place equal zero, and we have

$$\frac{2wal_2}{l} - w(x - l_1 + a) = 0.$$

We have also $l_1 + l_2 = l \quad \therefore \quad x = a\left(1 - \frac{2l_1}{l}\right) + l_1 \quad . \quad . \quad (2)$

Hence if $l_1 < \frac{1}{2}l$ ; $x > l_1$

$l_1 = \frac{1}{2}l$ $\quad$ $x = l_1$

$l_1 > \frac{1}{2}l$ $\quad$ $x < l_1$

So that the maximum strain is at the centre of the loading only when

the centre of the loading is over the middle of the beam; and *in all other cases it is nearer the middle of the beam than the centre of the load is.*

To find the maximum strain, substitute the value of $x$, Eq. (2), in expression (1).

Weisbach, vol. i. p. 209, gives the following example:

"What load may a hollow cast-iron beam sustain. if its outer depth and breadth be 8 inches and 4 inches, and inner depth and breadth 6 inches and 2 inches; and if, further, the middle of the load, uniformly distributed over 3 feet in length, is distant from one support 4, and the other 2 feet?"

If $\frac{1}{6}R = 1000$ lbs., we shall have, for the strength of the *dangerous section*, from the well known formula,

$$\tfrac{1}{6}R\,\frac{bd^3 - b_1d_1^3}{d} = 1000\,\frac{4\times 512 - 2\times 216}{8} = 202000.$$

On the hypothesis that the *dangerous section* is at the centre of the loading, we make $x = l_1$ in (1), which reduces it to $\dfrac{2wal_1l_2}{l} - \dfrac{wa^2}{2}$ which must equal 202000, or by substituting $l_1$, $l_2$ and $a$ we have $23wa = 202000$.

$$\therefore \quad 2wa = 17565 \text{ lbs. as found by Weisbach.}$$

But from Eq. (2) we find that the *dangerous section* is

$$x = \tfrac{3}{2}\left(1 - \tfrac{2}{3}\right) + 2 = 2\tfrac{1}{2} \text{ ft.} = 30 \text{ inches from A.}$$

This substituted in (1) gives

$$432w = 202000$$

$$\therefore \quad w = \frac{202000}{432}$$

$$\therefore \quad 2aw = 36w = \frac{202000 \times 36}{432} = 16833 \text{ lbs.}$$

Hence Weisbach's hypothesis gives too much by $17565 - 16833 = 732$ lbs., which is only a little more than 4 per cent. too much; a quantity which is fully provided for in the small co-efficient for rupture.

From Eq. (2) we see that the distance between the centre of the loading and the section of maximum strain is

$$x - l_1 = a\left(1 - \frac{2l_1}{l}\right) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Let AD $= y = l_1 - a \quad \therefore \quad a = l_1 - y$, which substituted in (3) gives

$$x - l_1 = (l_1 - y)\left(1 - \frac{2l_1}{l}\right)$$

which is evidently a maximum for $y = 0$, hence Eq. (3) is a maximum so far as the distance AD is concerned, when it (AD) is zero; or when one end of the load is over the support. For this condition $a = l_1$, which reduces (3) to

$$x - l_1 = l_1\left(1 - \frac{2l_1}{l}\right) \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Now, consider $l_1$ as the variable, and we find that (4) is a maximum

for $l_1 = \frac{1}{4}l$; or, $2l_1 = \frac{1}{2}l$; or the load must extend to the middle of the beam. For these conditions make $a = l_1 = \frac{1}{4}l$ in (3), (2), and (1), and we have

$$x - l_1 = \tfrac{1}{8}l$$
$$x = \tfrac{3}{8}l.$$

The maximum moment Eq. (1) is $= \frac{9}{128}\, wl^2 = w\frac{1}{2}l \times \frac{9}{64}\, l = \frac{9}{64}\, \mathrm{W}l$, in which W is the total load on one-half the beam.

The strain at the middle of the loading, when the load extends from one end to the middle of the beam, is $\frac{1}{8}\,\mathrm{W}l$; *hence*, the *maximum strain* is $\frac{9}{64}\,\mathrm{W}l \div \frac{1}{8}\,\mathrm{W}l = 1\frac{1}{8}$ *times that at the middle of the loading, when the load extends from one support to the middle of the beam.*

---

*Of the Beam fixed at both ends, and a load midway between the fixed points.*

Much has been said upon this case, on account of the discrepancy between theory and the results of experiment. Those who are familiar with the analytical solution of the problem, know that analysis shows that the beam is equally liable to break at the middle and at the ends, and that the moment of the strain at each of these three points is $\frac{1}{8}\,\mathrm{P}l$, in which

P = the load at the middle.

$l$ = the distance between the fixed points.

If the beam be *supported* at its ends, the strain would be $\frac{1}{4}\,\mathrm{P}l$; hence the strains are as 2 to 1.

Barlow, in his Treatise on the Strength of Materials, pp. 35 and 138, says their strengths are to each other as 3 to 2.

On pages 125 and 126 of the same work, he explains how the experiments were made.

I do not propose to solve the problem, but make these remarks for those who are familiar with it. Barlow, in the work referred to, attempts a solution in which he deduces the ratio already given, viz: 3 to 2, but I think an error has crept into his reasoning, which I will proceed to point out. He says (Art. 53) "it is shown that it requires *four* times the weight to produce the same deflection in the beam supported at each end, as is requisite to produce the same quantity in a beam of half the length."

*Fig 2*

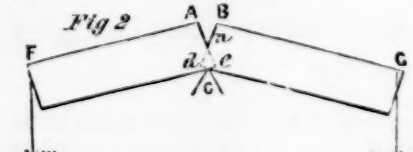
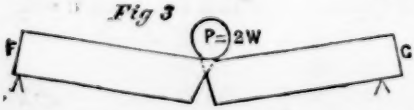



*Fig 3*




By referring to Article 35, I find that he arrives at this conclusion by assuming that in the deflection the fibres are nowhere elongated or compressed, except those directly over the support C, fig. (2); or under the weight P, fig. (3). With this view, his conclusion is correct: but the view is erroneous. For all the fibres from A to C, on one side, are elongated; and, on the other, compressed. During

flexure there is no such opening as AnB, as is represented in the figure. It is one of the fundamental principles of flexure, that sections which are normal to the axis of the beam before flexure, will be normal to the neutral axis after flexure; hence, the surfaces Ae and Bd coincide and remain in a vertical plane. With this view of the question, the preceding quotation should read: "It requires twice the weight, &c." And then Barlow would obtain the same results as other theorists.

But now arises the real difficulty. Barlow records a series of experiments (p. 138 of his work) on beams whose ends are fixed in a wall, and it appears from these that the ratio should be nearly as 3 to 2. He tries to explain the discrepancy, by assuming that the case investigated by theorists is different from the one under consideration, inasmuch as *they* suppose that the beam is extended beyond the support, and the beam is *fixed* by a force sufficient to make the tangent to the curve horizontal over the support. The fallacy which he introduced in the problem of the deflection of a beam supported at its ends, has entered into this; and the explanation which I have made of the former is applicable to the latter.

We are, moreover, confirmed in our view that the two cases which Barlow mentions, are essentially the same, from the fact that a beam which has one end fixed in a wall, and the other acted upon by a force, gives the same results as a beam of double the length supported at the middle, and acted upon at each end by the same force.

M. Navier, in his *Résumé des Leçons sur l'Application de la Mécanique*, p. 189, remarks: "It is difficult, in experiments to realizes the hypothesis of fixedness at the extremities." Also, "The reaction of the supports, as shown by theory, will be infinite, if the prolonged part be zero." This probably states the greatest difficulty, but it may be nearly, if not quite, overcome by a method suggested by Mr. Cooper, p. 195, vol. xli, 3rd series of this *Journal*. His suggestion is to extend the beam over several supports, and load it with a weight, P, midway between each.

There is, however, one element in this problem which does not enter into that of a beam supported at the ends, and which has not, so far as I know, received any attention. It is the stretching of the neutral axis. In the analysis we assume that the neutral axis retains its original length during flexure; but it is evident that if the ends be *fixed*, no flexure can take place without elongating the axis. For this reason the neutral axis cannot coincide with the axis of the beam, but inclines to the concave side throughout, as shown in fig. (4). So much of the force as is absorbed in producing this elongation, must be subtracted from the modulus of rupture, in determining the moment of resistance. This elongation will be small, but it should not be neglected in comparing theory with experiment.

*Fig 4*

Inasmuch as the resistance to flexure varies inversely as *the cube of the depth*, and the strength directly as *the square of the depth*, I would

suggest, that in applying Mr. Cooper's method, the depth of the beam be large compared with the breadth, so as to make the deflection small, and thus stretch the neutral axis as little as possible.

---

*Of the strength of a rectangular beam when the force is not applied perpendicular to either surface.*

Writers upon the strength of beams usually assume that when a beam is subjected to a force which is inclined to its side, the neutral surface is perpendicular to the direction of the force. This does not appear to me to be true in all cases, for when the beam is thin and considerably inclined, it will break by being deflected sidewise, and not wholly in the direction of the force. But in practical cases a thin beam would not be so placed as to have its sides inclined to the direction of the force, and if the beam were nearly square, the deviation from the ordinary hypothesis must be small. In all cases, whether the beam be very narrow compared with its depth, or nearly square —if the direction of the force coincides with the diagonal of the section, the neutral surface will, I think, be perpendicular to the direction of the force. Suppose, then, that

*A rectangular beam is acted upon by a force which is inclined to its sides, it is required to find its strength in all positions; also its inclination for a maximum and minimum strength*—in all cases assuming that the neutral surface is perpendicular to the direction of the force.

I will suppose that the force is vertical and the beam inclined.

Let ABCD be the section, HJ the neutral axis, angle AHJ = $x$.

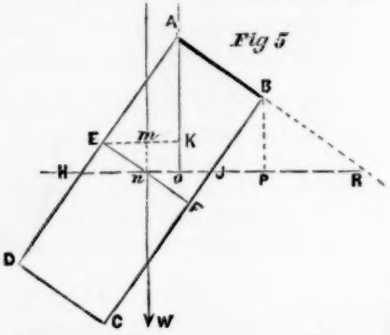


*Fig 5*

I = moment of inertia of the section.

$d_1$ = Ao = distance of most remote fibre from the neutral axis.

R = modulus of strength.

$d$ = AD  $b$ = AB.

Then

$R\frac{I}{d_1}$ = the strength of the beam at this section.

The moment of inertia of the whole section is twice the moment of AHJB, and the moment of AHJB is equal to the moment of the triangle HAR *minus* the moment of BJR. The moment of inertia of the triangle AHR about its base HR, is $\frac{1}{12}$ (HR)$\times$ (AO)$^3$, that of BJR is $\frac{1}{12}$ (JR) $\times$ (BP)$^3$.

Let $k_1$ = area AHR.

$k_2$ = area BJR.

$d_2$ = BP.

$k$ = area AHJB.

Then the moment of inertia of ABJH becomes

$$\tfrac{1}{12}\,\text{H}\,\text{R}\,.\,d_1^3 - \tfrac{1}{12}\,\text{J}\,\text{R}\,d_2^3 = \tfrac{1}{6}\,[k_1 d_1^2 - k_2 d_2^2] \quad . \quad . \quad (1)$$

Because of the similarity of triangles, we have

$$k_1 : k_2 :: d_1^2 : d_2^2 \quad \therefore k_2 = \frac{k_1 d_2^2}{d_1^2}$$

also, $k_1 - k_2$. or $k : k_1 :: d_1^2 - d_2^2 : d_1^2$.

These reduce (1) to $\frac{1}{6}\,k\,(d_1^2 + d_2^2)$ . . . . . (2)

But $d_1 = \text{A}\,\text{K} + \text{K}\,\text{O} = \frac{1}{2}\,d \sin. x + \frac{1}{2}\,b \cos. x$ . . . . . (3)

$d_2 = \frac{1}{2}\,d \sin. x - \frac{1}{2}\,b \cos. x$

These substituted in (2) give

$$\tfrac{1}{12}\,k\,(d^2 \sin.^2 x + b^2 \cos.^2 x)$$

And the moment of the whole area becomes

$$\text{I} = \tfrac{1}{12}\,2\,k\,(d^2 \sin.^2 x + b^2 \cos.^2 x) = \tfrac{1}{12}\,bd\,(d^2 \sin.^2 x + b^2 \cos.^2 x) \quad (4)$$

Equations (3) and (4) give

$$\text{R}\,\frac{\text{I}}{d_1} = \tfrac{1}{6}\,\text{R}\,\frac{b\,d\,(d^2 \sin.^2 x + b^2 \cos.^2 x)}{d \sin. x + b \cos. x} \quad . \quad . \quad (6)$$

This is the result reached by all analysts.

If $x = 90°$ Eq. (6) becomes $\frac{1}{6}\,\text{R}\,b\,d^2$

" $x = 0$ " " " " $\frac{1}{6}\,\text{R}\,b^2 d$.

To find the inclination so as to give a minimum strength, make the first differential co-efficient of Eq. (6) equal zero. This gives $0 =$ $(d^3 - 2b^2 d) \sin.^2 x \cos. x + (2b\,d^2 - b^3) \sin. x \cos.^2 x + b\,d^2 \sin.^3 x - b^2 d \cos.^3 x$.

But $\sin.^3 x = \sin. x\,(1 - \cos.^2 x)$ and $\cos.^3 x = \cos. x (1 - \sin.^2 x)$ which will reduce the preceding equation to

$(d^3 - b^2 d) \sin.^2 x \cos. x + (b\,d^2 - b^3) \sin. x \cos.^2 x + b\,d^2 \sin. x - b^2\,d \cos. x = 0$.

In this substitute $\sin. x = \sqrt{1 - \cos.^2 x}$ and reduce, and we obtain $[-(b\,d^2 - b^3)^2 - (d^3 - b^3\,d)^2] \cos.^6 x + [(b\,d^2 - b^3)^2 - 2\,(b\,d^2 - b^3)$ $b\,d^2 - 2\,(2\,b^2\,d - d^3)\,(d^3 - b^2\,d)] \cos.^4 x + [2\,(b\,d^2 - b^3)\,b\,d^2 - b^2\,d^4 -$ $(2\,b^2\,d - d^3)^2] \cos.^2 x = -b^2\,d^4$ . . . . . (7)

*Discussion of Equation* (7)

1. Let $d = n\,b$; then we have $(n^6 - n^4 - n^2 + 1) \cos.^6 x - (2\,n^6 - 7\,n^4 + 4\,n^2 + 1) \cos.^4 x + (n^6 -$ $5\,n^4 + 6\,n^2) \cos.^2 x = n^4$ (8); hence the angle depends only upon the ratio of the sides.

2. Let $n = 1$.

This reduces Eq. (8) to $\cos.^2 x = \frac{1}{2}$.

$$\therefore \cos. x = \pm \sqrt{\tfrac{1}{2}}. \quad \therefore x = 45° \text{ or } 135°$$

These values in Eq. (6) give

$$\frac{\text{R}\,b^3}{\sqrt{2}} = \tfrac{1}{6}\,\text{R}\,b^3 \times 0{\cdot}70710 +, \text{ for the strength of the beam.}$$

If $b = d$ and $x = 90°$ in Eq. (6) we find $\frac{1}{6}\,\text{R}\,b^3$ for the strength of the beam.

Hence the strength of a square beam with its side vertical, is to the

strength of the same beam with its diagonal vertical as 1 to 0·70710. But if the condition be that the beam shall in both cases be completely severed, then the latter fraction must be multiplied by 1·09125 +, as shown in my article on triangular beams, in vol. xli. p. 201 of this *Journal*. Then the ratio becomes as 1 to 0·77162 +.

3. Let $n=2$ and $\cos.^2 x = y$

Then Eq. (8) will reduce to

$$y^3 - \tfrac{3}{4}\tfrac{3}{5} y^2 + \tfrac{8}{4}\tfrac{}{5} y = \tfrac{1}{4}\tfrac{6}{5} \quad . \quad . \quad . \quad . \quad (9)$$

To make the second term disappear, make $y = z + \frac{11}{45}$, and substitute in Eq. (9), which reduces it to

$$z^3 - \frac{3}{45^2} z = \frac{31102}{45^3}$$

This solved gives $z = 0{\cdot}70112 +$

$$\therefore y = 0{\cdot}94556 + = \cos.^2 x$$

$$\therefore \cos. x = +\,0{\cdot}9723 +$$

$$\therefore x = 13^\circ\ 30' \text{ or } 166^\circ\ 30'$$

making $d = 2b$ in Eq. (6), we have for the strength of the beam

when $x = 13^\circ\ 30'$ ; $\frac{1}{3}\,\mathrm{R}\,b^3 \times 0.8295 +$

" $x = 0^\circ$ ; $\frac{1}{3}\,\mathrm{R}\,b^3$

" $x = 90^\circ$ ; $\frac{2}{3}\,\mathrm{R}\,b^3$

It is probable that in the inclined position, the angle would fracture before the beam is loaded to its ultimate strength, but the investigation for determining it would be tedious and unprofitable. Whether this be the case or not, we *see that the beam is not weakest when it rests on its broad side.*

The other two roots of Equation (9) are imaginary; hence, the equation does not indicate the position of maximum strength. This is because the value of Eq. (9) increases as $y$ increases indefinitely; but all possible inclinations of the beam are included between $\cos.^2 x = y = 0$ and $\cos.^2 x = y = 1$, the former of which gives the position of greatest strength when $d$ is greater than $b$; and the latter when $b$ is greater than $d$.

We might proceed to make other suppositions on $n$, but enough has already been given to illustrate the mode of procedure. Equation (8) can be solved for all possible values of $n$, for it is of the form of a cubic equation.

3. If $n$ is infinite, we may omit all the inferior powers in each factor in Eq. (8) and thus obtain

$$n^6 \cos.^6 x - 2n^6 \cos.^4 x + n^6 \cos.^2 x = n^4$$

$$\text{or } \cos.^6 x - 2\cos.^4 x + \cos.^2 x = \frac{1}{n^2} = \frac{1}{\infty^2} = 0$$

the roots of which are

$$\cos. x = 0^\circ \qquad \cos. x^2 = \pm 1$$

$$\therefore x = 90^\circ \qquad x = 0^\circ \text{ or } 180^\circ$$

The former value of $x$ gives the position for maximum; the latter, for minimum. This is the case of a very thin beam.

4. Let $n = 0$. This is also the case of an infinitely thin beam, but $b$ is the greater quantity. Eq. (8) becomes

$$\cos.^6 x - \cos.^4 x = 0$$
$$\therefore \cos. x = 0 \text{ or } \cos.^2 x = 1$$
$$\therefore x = 90° \text{ or } x = 0° \text{ or } 180°$$

the former of which gives the position for a minimum, and the latter for maximum strength.

It appears that the side of the beam may be so inclined as to have the same strength as when it rests on its broad side, and the angle of inclination which will fulfil this condition, may be found by making Eq. (6) equal $\frac{1}{3}$ R $b^2 d$.

This done, cos. $x$ eliminated, and a reduction made, gives;

$$(d^2 - b^2)^2 \sin.^3 x - 2 (d^2 - b^2) b d \sin.^2 x + (3 b^2 d^2 - b^4) \sin. x = 2 b^3 d$$

If $d = n b$, we have

$$(n^2 - 1)^2 \sin.^3 x - 2 (n^2 - 1) n \sin.^2 x + (3 n^2 - 1) \sin. x = 2 n.$$

If $n = 2$, we have

$$\sin.^3 x - \frac{4}{3} \sin.^2 x + \frac{11}{9} \sin. x = \frac{4}{9}$$

Make $\sin. x = y$ and $y = z + \frac{4}{9}$ and we have

$$z^3 + \frac{5}{8}\frac{1}{1} z = \frac{5}{9}\frac{6}{3}$$

which solved by Cardan's formula gives

$$z = 0{\cdot}11929 \quad \therefore y = 0{\cdot}56473 = \sin. x$$
$$\therefore x = 34° \; 23'.$$

To prove the truth of the result, substitute this value of $x$ in Eq.(6). The other two roots are imaginary.

---

Translated for the Journal of the Franklin Institute.

## *Restoration of Old Wood-cuts.*

The French Journals speak of an invention by M. Coblence by which "is restored to the most worn out wood-cuts all its primitive sharpness, and it can be electrotyped as perfectly as a new one." The means by which this is done are not yet published, but the editor of one of the Journals certifies that he has seen the proofs taken from the *clichés* thus made, and that they have all the sharpness of first proofs, although the blocks had been used for a great number of editions.

The value of such a discovery, if there be any truth in it, can hardly be over-estimated.

---

## *On Eight Scientific Balloon Ascents.* By Mr. Glaisher.

From the London Athenæum, Oct., 1862.

The author first said, all philosophical inquiries carried on near the surface of the earth, are, of necessity, fully within its influence, and, consequently, of many disturbing causes. All experiments thus conducted are affected by radiation; conduction and reflection of heat; of reflection of rays of light, of currents of air, of the effect of large or small

evaporating surfaces on the one hand, or of large or small condensing surfaces on the other; and of many other disturbing causes, all of which are sources of error, and from the effect of which we cannot escape even by going to the top of the highest mountains. By no other means than by the use of the balloon can we free ourselves from these disturbing influences; and the question has often been asked, particularly since the formation of the British Association, whether or not the balloon affords a means of accomplishing with advantage the solution of many questions in physics which are seriously affected by them?—whether, for instance, delicate and accurate observations can be made by these?—whether an observer in such a position can be at his ease, so as to be able to observe as well as on the earth?—whether these observations can be made with tolerable safety to himself, &c.? To answer these questions, it was necessary to ascend in a balloon; and it seemed to Mr. Glaisher that their solution was well worth the venture. The author then said, let us consider for a moment what science would be benefited from experiments under the circumstances of being free from so many sources of error. These are, meteorology and astronomy, and all allied sciences, certainly; chemistry and magnetism, &c., probably. Perhaps, of all branches of physical research the greatest advantage would accrue to meteorology and to astronomy; and when we regard the influence which a clear sky or a cloudy one exercises on the temperature and weather, and what an important part the condition of the sky exercises upon our comfort and well-being generally, there seems to be a high probability that by studying the laws which govern the higher strata of the air, and cultivating some acquaintance with these regions themselves, our knowledge of aërial phenomena could be greatly increased: and with regard to astronomy, there is no more important point in the whole range of physical research, to which experiments can be devoted, than to improving our knowledge of the laws of refraction, when it is recollected that the true position of every heavenly body is dependent upon our correct knowledge of these laws. He then detailed the object of the experiments as follows:—The primary objects of the experiments were—the determination of the temperature of the air and its hygrometric state at different elevations, up to 5 miles. The secondary objects were—to compare the readings of an aneroid barometer with those of a mercurial barometer up to 5 miles; to determine the electrical state of the atmosphere; to determine the oxygenic condition of the atmosphere by means of ozone papers; to determine the time of vibration of a magnet on the earth and at different distances from it; to determine the temperature of the dew-point by Daniell's dew-point Hygrometer and Regnault's Condensing Hygrometer, and by the use of the dry and wet bulb thermometers as ordinarily used, and by their use when under the influence of the aspirator, so that considerable volumes of air were made to pass over both bulbs at different elevations, as high as possible, but particularly up to those heights where man may be resident, or where troops may be located, as in the high lands and plains of India, with the view of ascertaining what confi-

dence may be placed in the use of the dry and wet bulb thermometers at those elevations, by comparison with those found directly by Daniell's and Regnault's Hygrometers, and also to compare the results as found by the two Hygrometers together: to collect air at different elevations; to note the height and kind of clouds, their density and thickness at different elevations; to determine the rate and direction of different currents in the atmosphere, if possible; to make observation on sound; to note atmospherical phenomena in general, and to make general observations. The instruments used consisted of mercurial and aneroid barometers; dry and wet bulb thermometers, also an exceedingly sensitive thermometer; Daniell's Dew-point Hygrometer; Regnault's Condensing Hygrometer; solar radiation thermometer; maximum and minimum thermometers; a small magnet for horizontal vibrations, hermetically sealed, and exhausted glass-tubes; ozone test-papers, &c. All the instruments were constructed by Messrs. Negretti & Zambra, excepting the mercurial barometer, which was entrusted to Mr. P. Adre, of London. He then detailed the instruments, the observing arrangements, and the circumstances of the ascents, of which three were made from Wolvérhampton, on July 17, August 18, and September 5; four from the Crystal Palace, viz: on July 30, August 20, September 1, and September 8; and one from Mill Hill, near Hendon, where the balloon had fallen the night before, and where it had been anchored during the night. In the ascent on July 17, a height of 26,177 feet was reached; and in the descent a mass of vapor of 8000 feet in thickness was passed through, so dense that the balloon was not visible from the car. In that of August 18, an altitude of 11,500 feet was attained: then the balloon descended to 3200 feet; then ascended to 23,400 feet, where a consultation took place, and it was decided not to go higher, as clouds of unknown thickness and moisture had to be passed through. In the ascent on August 20, the air was almost calm; the balloon for a long time hovered over the Crystal Palace, and then over London, whilst it was lighted up, where they seemed to be destined to remain all night; finally, went above the clouds, and came down at night near Hendon. The balloon was then anchored for the night, the lower valve being closed with the hope that the gas would be retained. Before sunrise, on August 21, all the instruments were replaced and the balloon left the earth. It was a warm, dull, cloudy morning; clouds were reached at the height of 5000 feet; the light rapidly increased, and gradually the balloon emerged from dense clouds into a basin surrounded with immense black mountains of cloud, rising far above; shortly afterwards there were deep ravines of grand proportions below, bounded with beautiful curved lines. The sky was blue with cirri. The tops of the mountain-like clouds became silvery and golden; at the height of 8000 feet we were on their level, and the sun appeared flooding with golden light all space for many degrees, both right and left, tinting with orange and silver all the remaining space. It was a glorious sight. As the sun's rays fell on the balloon we rose more

rapidly, each instant opening to us ravines of wonderful extent, and presenting elsewhere a mighty sea of cloud. Here there were shining masses in mountain chains, some rising perpendicularly from the plains, dark on one side, and silvery and bright on the other, with summits of dazzling whiteness; some there were of a pyramidal form, a large portion undulatory, and in the horizon Alpine ranges bounded the view. A height of nearly three miles was reached. On Sept. 1, when at the height of three-quarters of a mile over London, the whole course of the river Thames was visible from its mouth; and parallel to it, and bounded by its banks, a cloud or fog-bank extended the whole distance, following all its sinuosities. For half an hour before the descent, near Woking, in Surrey, the balloon was under one stratum of cloud and above another; the upper surface of the latter was remarked as bluish white, the middle portion the pure white of the cumulus, and the lower surface a blackish white, and from which rain was falling on the earth. The balloon descended to a height of 1300 feet, but still above these clouds. It was afterwards learnt that rain had been falling from these clouds all the afternoon. On Sept. 5, the balloon ascended from Wolverhampton: at 29,000 feet from the earth Mr. Glaisher became insensible; the balloon still ascended to fully the height of 35,000 feet or 36,000 feet, and may have gone even higher. Mr. Glaisher recovered his consciousness on descending, when at about the same height he lost it on ascending. The author had prepared and exhibited diagrams showing the path of the balloon and temperatures of the air at different elevations for each ascent, and extensive tables of all his observations. From these he deduced the following table, showing the mean temperature of the air at every 5000 feet of elevation above the level of the sea in each high ascent:—

| Height above the level of the Sea. | Mean Temperature of the Air. | | | | | Decrease of Temperature for an increase of height of 5000 feet. |
|---|---|---|---|---|---|---|
| | July 17. | August 18. | August 21. | September 5. | Mean. | |
| Feet. | Degrees. | Degrees. | Degrees. | Degrees. | Degrees. | Degrees. |
| 0 | 61·2 | 69·6 | 62·0 | 62·2 | 63 8 | |
| 5,000 | 39·7 | 48·0 | 43·3 | 41·4 | 43·1 | 20·7 |
| 10,000 | 28·0 | 40·7 | 32·0 | 31 0 | 32·9 | 10·2 |
| 15,000 | 31·0 | 31·1 | 19·0 | 21·0 | 25·7 | 7·2 |
| 19,500 | 42·2 | | | | | |
| 20,000 | 33·0 | 25·9 | | 10 6 | 23·2 | 2·5 |
| 25,000 | 16·0 | 23 9 | | 0·0 | 13·3 | 9·9 |
| 30,000 | | | | –5·3 | | |
| Decrease of Temperature for an increase of height of 25,000 feet, | 44·9 | 45·7 | | 62·2 | 50·5 | |

The results on July 17 are perfectly anomalous. Up to 10,000 feet

the decrease accords with the other days of experiments; but from 10,000 feet the results are perfectly surprising, and continue so up to more than 20,000 feet. Above 25,000 feet they are again accordant. If we suppose that up to 10,000 feet and again to 25,000 feet the results are not abnormal, by continuing the curve joining these two portions, and then reading, we should have the following readings, viz:—at 0 ft. the mean temperature was 61°·2; at 5000 feet, 39°·7; at 10,000 feet, 27°·5; at 15,000 feet, 22°·7; at 19,500 feet, 20° 0; at 20,000 feet, 19°·5; at 25,000 feet, 16°·3. Then the measure of disturbance would be as follows:—At 10,000 feet, 0°·5 in excess; at 15,000 feet, 8°·3 in excess; at 19,500 feet, 22°·2 in excess; at 20,000 feet, 13°·5 in excess; at 25,000 feet, 0°·3 in defect. The numbers in the last column of the table show that the average decrease of temperature in the first 5000 feet exceeds 20°, and in the next 5000 feet is but little more than 10°. The numbers in the lowest line of the table show that the average decrease of temperature for 25,000 feet is 51° nearly. From these numbers it seems that two-fifths of the whole decrease of temperature in 5 miles takes place in the first mile, and therefore that the decrement is not uniform with the increment of elevation. The author then discussed the observations up to 1 mile in all the eight ascents. The following table shows the mean temperature of the air at every 1000 feet up to 5000 feet on the days of the balloon's ascent:—

| Height. | July 17. | July 30. | Aug. 18. | Aug. 20. | Aug. 21. | Sept. 1. | Sept. 5. | Sept. 8. | Mean. | Effect of 1000 ft. |
|---|---|---|---|---|---|---|---|---|---|---|
| Feet. | Degrees. | Degrees. | Degrees. | Degrees. | Degrees. | Degrees. | Degrees. | Degrees | Degrees. | Degrees. |
| 0 | 61·2 | 70·0 | 69·6 | 66·8 | 62·0 | 67·0 | 62·2 | 69·7 | 66·1 | |
| 1000 | 57·0 | 63·0 | 62·0 | 62·0 | 58·0 | 59·8 | 57·8 | 65·0 | 60·6 | 5·5 |
| 2000 | 52·6 | 56·8 | 56·5 | 57·0 | 54·0 | 53·2 | 53·0 | 60·4 | 55·4 | 5·2 |
| 3000 | 48·3 | 52·2 | 53·3 | 52·7 | 50·3 | 49·2 | 48·7 | 55·7 | 51·3 | 4·1 |
| 4000 | 44·0 | 49·8 | 50·4 | 49·0 | 46·9 | 47·7 | 45·0 | 51·5 | 48·0 | 3·3 |
| 5000 | 39·7 | 47·0 | 48·0 | 45·0 | 43·8 | 46·0 | 41·4 | 48·4 | 44·8 | 3·2 |
| Effect of an elevation of 5000 feet, | 21·5 | 23·0 | 21·6 | 21·8 | 18·7 | 21·0 | 20·8 | 21·3 | 21·3 | |

From this table we learn that the mean decrease of temperature of the air exceeds 21° for the first mile, and from the last column that the rate of the decrease of temperature in the atmosphere is not uniform up to 5000 feet. These results are based upon observations including clear and cloudy states of the sky: in the former the differences would be larger, and in the latter they would be smaller. The author then spoke upon the electrical state of the air, which he found charged with positive electricity, decreasing in amount with elevation. With respect to ozone, he said none was shown in the earlier ascents, but that large quantities were shown in the latter, and attributed the deficiency in the former to bad paper. He remarked, that diminished pressure exercised a very different influence upon different individuals, dependent probably upon temperament and organization; that the effect of high elevation was different upon the same individual at different times; that the time of the vibration of a magnet was somewhat longer

at high elevation than on the earth; that different notes and sounds pass more readily through the air than others, instancing that the barking of a dog can be heard two miles high, and the shouting of a multitude not one mile. The author concluded his paper with the following remarks:

These eight ascents have led me to conclude, Firstly, that it was necessary to employ a balloon containing nearly 90,000 cubic feet of gas, and that it was impossible to get so high as 6 miles, even with a balloon of this magnitude, unless carburetted hydrogen, varying in specific gravity from 370 to 340, had been supplied for the purpose. It is true that these statements are rather conflicting when compared with those made by one or two early travelers, who professed to have reached some miles in height with small balloons. But if we recollect that at 3¾ miles high a volume of gas will double its bulk, we have at once a ready means of determining how high a balloon can go; and in order to reach an elevation of 6 or 7 miles, it is obvious that one-third of the capacity of the balloon should be able to support the entire weight of the balloon, including sufficient ballast for the descent. The amount of ballast taken up affords another clue as to the power of reaching great heights. Gay-Lussac's ballast, as before mentioned, was 33 lbs. Rush and Green, when their barometers, as stated by them, stood at 11°, had only 70 lbs. left; and this was considered sufficient *playing* power. We found that it was desirable to reserve 500 or 600 lbs.; and although we could have gone much higher by saving less, still on every occasion it was evident that a large amount of ballast was indispensable to regulate the descent and select a favorite spot with the nicest accuracy. Secondly, it was manifest throughout our various journeys, that excessive altitude and extended range as to distance are quite incompatible. The readings of the instruments establish this; and it has been pointed out what a short time the balloon held its highest place, and how reluctantly it appeared to linger even at a somewhat less elevation. This was not owing to any leakage or imperfection in the balloon itself, for its efficiency has been well tested, and it remained intact a whole night without the least perceptible loss of gas. It has been stated by an aëronaut of experience that strong opposing upper currents have been heard to produce an audible contention, and to sound like the "*roaring of a hurricane.*" Now, the only deviation we experienced from the most perfect stillness, was a slight whining noise in the netting, and this only when the balloon was rising with great rapidity. The balloon itself, as it descends, flaps about occasionally; but this occurs when it is in a collapsed state, and very likely it was under similar circumstances, and perhaps during a rapid descent, that the flapping of the lower part of the balloon was mistaken for a roaring wind. I may also state that the too readily accepted theory as to the prevalence of a settled west or northwest wind was not confirmed in our trips; nor was the appearance of the upper surface of the clouds such as to establish the theory, that the clouds assume the counterpart of the earth's surface below, and rise or fall like hills and dales. The formation of vapor along the course, and during an ascent from the Crystal Palace, has already

been alluded to: this was a very remarkable demonstration. The principal results deduced from these observations may be briefly stated. That the temperature of the air does not decrease uniformly with height above the earth's surface, and that, consequently, more elucidation upon this point is required, particularly in its influence on the laws of refraction. That an aneroid barometer can be made to read correctly, certainly to the first place, and probably to the second place of decimals, to a pressure so low as 5 inches. That the humidity of the atmosphere does decrease with the height, with a wonderfully increasing rate, till at heights exceeding 5 miles, the amount of aqueous vapor in the atmosphere is very small indeed. That we now can answer the question I put in my opening remarks, and can say that observations up to 3 miles high, even of a delicate nature, can be made as comfortably in a balloon as on the earth; that at heights exceeding 4 miles they cannot be made quite so well, because of the personal distress of the observer; that at 5 miles high it requires the exercise of a strong will to make them at all. That up to 3 miles high any person may go in the car of a balloon who is possessed of an ordinary degree of self-possession. That no person with heart disease or pulmonary complaints should attempt 4 miles high. But, at the same time, it must be borne in mind that I am concluding that the balloon is properly handled. It has been fortunate for this Association and myself that we have had the assistance of Mr. Coxwell, who has the experience of more than 400 ascents, based upon knowledge of natural philosophy, and that he knows "the why and because" of all his operations; and it was this fact, which I saw immediately from the clearness of his explanation to me for each operation, that enabled me to dismiss from my mind all thoughts of my position, and to concentrate my whole energies upon my duties. In conclusion, I feel certain that if these experiments prove that the balloon is available for philosophical research, then one of the brightest links in the long chain of useful works, performed through the agency of the Association, will be the feeling that the balloon, in proper hands, may be made a powerful philosophic agent.

Proceedings Brit. Assoc.

---

For the Journal of the Franklin Institute.

## *Report on the Oil District of Oil Creek in the State of Pennsylvania.*

By THOMAS S. RIDGWAY, Geologist and Mining Engineer, of Cambridgeport, Mass., late Geologist to Maj. Gen. JOHN C. FREMONT in his Military Campaign in Western Virginia.

The oil district of Oil Creek in the State of Pennsylvania is situated in a shallow geological basin (sinclinal trough) whose bearing is nearly north and south, and yet having a gentle inclination in a southerly direction.

The strata of rock drilled into along the margin of Oil Creek are the Vergent Series of Prof. Rogers composed of compact close-grained

white and gray flaggy sandstones, alternating with red and olive-colored argillaceous shales. The beds of white and gray sandstones have been numbered by the drillers for oil on Oil Creek in the descending order Nos. 1, 2, 3, 4, and 5, commencing in the bottom land on Oil Creek below Titusville. This numbering answers very well along the margin of the streams in Venango County, but in the County of Crawford there is an important bed of sandstone to drillers laying above No. 1, and reposes immediately under the town of Titusville, which I shall name the Titusville bed, and another above this found back in the hills which I shall call the Quarry bed. There is also a group of beds of soft micaceous sandstones found overlaying the tops of the hills in the vicinity of Titusville, which I shall name the Top Group of Rocks of the Oil Bearing Strata. This group is capped in some places by the Vespertin Conglomerate Rocks of Prof. Rogers.

Here we have a mass of Oil Bearing Strata of about 1200 feet in thickness largely saturated with petroleum from the Vespertine Conglomerate down to the Genesee slates. A formation very little disturbed from its original nearly horizontal position, save the slight swells and depressions crossing the oil trough obliquely. The molten plutenic waves which broke up the crust of the earth in northern Pennsylvania appear to have died out and rounded out towards the lakes, for one does not find here the huge anticlinal and sinclinal axial lines as in central Pennsylvania, but instead, feeble lines of elevation and depression crossing an original trough or basin of the Devonian Sea. In proof of this, I find the Oil Bearing Strata broken up into huge cakes of sandstones and shales, having fissures or openings between the strata extending down to a great depth, and which are generally found filled with gravel and pebbles, the result of the Drift Formation. These openings are numerous in the valley of Oil Creek, and the cause of much perplexity to drillers in search of oil. Parties sinking test holes for oil have driven iron pipe (a process which obviates boring through sand and gravel to the rock) down into some of these openings to the surprising depth of 160 feet from the surface of the country before striking the permanent rock, whilst their neighbors only a few yards distant have reached the horizontal strata at a depth of 30 or 40 feet. On Samuel Machintire's farm, 1½ miles west of the Rynd farm, there may be seen one of these vertical fissures in the strata above water free, where a man may walk under ground for the distance of 170 feet and look up 100 feet high. Similar openings may be seen near the Pit Hole, one of the tributary streams of the Alleghany river. They seldom contain oil in quantity. I therefore infer that they are lines of elevation, and the oil in the rock flows from them.

The lowest members of the Oil Bearing Strata commence in the vicinity of the town of Waterford, in Erie County, Pennsylvania, and incline gently in a southerly direction to the town of Union, where they disappear beneath the range of hills south of that village. About 8 miles to the south of this, we find Chestnut Ridge, where the Oil Bearing Strata are complete, but incline at an angle of 10 degrees to

the south to Hidetown, so that the majority of the oil flows in the direction of Oil Creek. There is a sinclinal trough in the strata beneath the town of Titusville and an anticlinal roll crossing at the lower dam near the Stackpole farm, and from this point there are a series of small undulations and crimps in the strata all the way to the mouth of Oil Creek. The stream running step-like denuding its passage nearer and nearer to the great oil pool below, where a depth of 530 feet from the surface produce flowing wells for a distance of 7 miles near to the mouth of Oil Creek.

The out-croppings of the lowest members of the Oil Bearing Strata are quarried at points along the line of the "Philadelphia and Erie Railroad," in Erie County, Pennsylvania, and the stones taken out are used for building purposes. The foundation walls of Mr. Riley's Hotel in the town of Union was built altogether of stone from one of these quarries, and the petroleum oozes out, staining the face of the walls to a great extent.

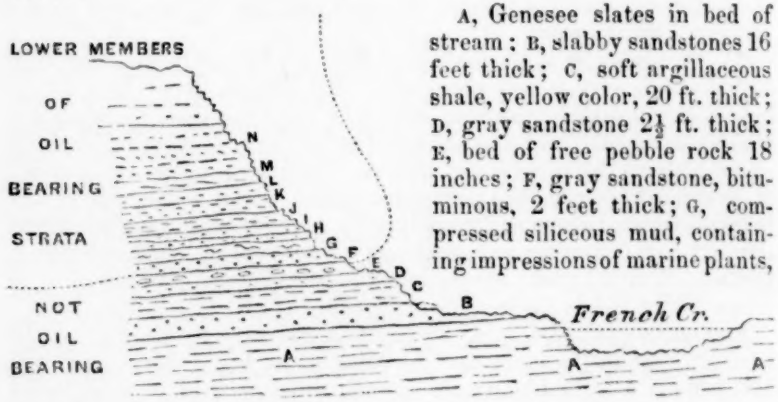
The Academy in Waterford, Erie County, Pennsylvania, was built 41 years ago with stones quarried on Big French Creek from fourth sand rock (so called); the petroleum still oozes out from the walls and trickles down the front and sides of the building, disfiguring its front so much up to the present day that the Academy commissioners resort to painting to conceal the petroleum stains. The north side of the building which I examined closely with a magnifying glass (to ascertain if I could discover any marks or impressions of fossil remains to produce oil in the rock) is very much disfigured, and portions of it so much so that it has the surface appearance of an old oily iron pot.

Such facts as the foregoing led me to a course of reasoning that the oil must exist in the rock, and the cause of its being there must have arisen from a buried vegetable growth which took place prior to the so-called carboniferous clay. For the petroleum to have flowed from the coal fields up hill in a northerly direction against the inclination of the strata, and found to exist in these particular beds of sandstone and shale, and not in the overlaying rocks, is an impossibility. And for the oil to have flowed from the true carboniferous deposite, before its elevation or subsidence of the waters, to points where the towns of Union and Waterford now stand, is poor reasoning, for the oil would have raised to the surface of the waters before running so far to settle in the Devonian Formation far below the carboniferous strata.

Knowing that the lowest coal beds of our coal fields are generally found to be the thickest, and were produced from a rank growth of vegetation, I supposed that there may have been a great mass of marine plants washed into the trough of the Devonian Sea immediately above the Genesee slate far below the valley of Oil Creek at the time the sand was laid down to form sand rock, and by their decomposition produced the rock oil; hence I kept a steady eye on each layer of rock as it presented itself to me in exposed places in hopes that the Stony Book of God, whose pages might be the true authorities in the case, should reveal to me in a suit of fossils the true cause of rock oil so deep

and so far from the coal fields. And I am pleased to state that the result of my investigations has far exceeded my anticipations, by the discovery of a great profusion of impressions of marine plants of the fucoid family in micaceous slabby sandstones along the edge of the base of the hills from the Stackpole farm 2½ miles below Titusville to the mouth of Cherry Tree Run. This encouraged me to make a thorough examination of the out-croppings of the Oil Bearing Formation. I proceeded at once to Big French and Le Boeuff Creeks in Erie County, where I found above the Genesee slates a bed of siliceous mud filled with impressions of marine plants and possessing a strong bituminous odor.

The following diagram is a geological column taken on the spot, September, 1861, about 5 miles from the town of Union on Big French Creek:




A, Genesee slates in bed of stream; B, slabby sandstones 16 feet thick; C, soft argillaceous shale, yellow color, 20 ft. thick; D, gray sandstone 2½ ft. thick; E, bed of free pebble rock 18 inches; F, gray sandstone, bituminous, 2 feet thick; G, compressed siliceous mud, containing impressions of marine plants, highly bituminous, 2 feet thick; H, micaceous sandstone, bituminous, 1 foot; I, hard sandstone, bituminous, 10 inches; J, soft olive-colored shale, bituminous, 2 feet; K, soft slabby sandstone, bituminous, 6 ft.; L, hard sandstone, embracing irregular seams of quartz pebbles, bituminous, 4 feet; M, argillaceous shale, light color, bituminous, 2 ft.; N, gray sandstone, containing thin bands of hard sandstone, bituminous, 45 feet thick.

On examining the slopes of the hills in this vicinity I saw petroleum oozing out from their sides above the bed of free pebble rock, E; but below this stratum there was not the least indication of petroleum issuing from their slopes, and no bituminous odor arising from any of the rocks below this point when struck with a hammer. Now, if one could follow the bed of siliceous mud, G, to its deep pool below the valley of Oil Creek, he no doubt would behold a sheet of oil, the result of fermentation of a large mass of marine plants that at one time grew upon the floor of the Devonian Sea, many of which may have been washed into this sinclinal trough by currents of salt water or by its oscillatory motion, for ripple washings may be distinctly seen upon the Oil Creek flags.

The plants which produced the oil in the rock existed and flourished at a long period of time before the vegetation which now forms coal beds; they are unlike the vegetable impressions found in the accompanying shales and clays associated with beds of coal, and grew when the flagstones and shales of Oil Creek were laid down by salt water currents, the sand rock then being sand and the shale mud, which caught and filled away in the secret chambers of the deep every new vegetable growth from the pebble rock, E, beneath the oil pool up to the top of the Oil Bearing Strata.

The climate was so hot during this age of marine vegetation, and the growth of plants so rapid and rank, caused by the supposed large amount of carbonic acid gas and hydrogen then composing the atmosphere, that these conditions on the face of the earth produced plants containing less carbon and more hydrogen than the plants which produced coal beds, hence the fermentation produced oil, now petroleum. Had these marine plants taken up more carbon and less hydrogen than by fermentation they would have produced seams of coal. The discovery by me of a thin seam of bituminous coal in the upper members of this Oil Bearing Formation aids to substantiate the theory advanced, for the ancient marine vegetation which produced the petroleum in the Devonian Formation, gradually passed into a more carboniferous one.

Petroleum found in bituminous coal basins no doubt originates from beds of coal. Rock Oil found in other districts of North America may be derived from the decomposition of animal tissue, but it is my opinion that the petroleum of Oil Creek Valley, Pennsylvania, is the result of the decomposition of marine plants. Oils derived from animal origin have an offensive odor, whereas the oils from vegetable matter has a more pleasant odor. If their chemical compositions should be similar, their physical characteristics are entirely different. Oil found in bituminous coal fields is of a brown color, whereas the oil found in Oil Creek Valley is of a greenish hue. The substance iodine at the present day is found to exist in sea plants, but it may not have existed in the marine plants that produced the oil of Oil Creek.

The oil of Oil Creek is the result of fermentation of vegetable matter of long standing, and the carburetted hydrogen gas evolved was "cabined, cribbed, confined" for a long period of time until the boring tools probed it to the great pool below, then this gas became the chief agent in bringing the oil to the surface, producing spouting wells whose yield has been from 200 to 2000 barrels of petroleum each per day.

---

## *Water-Proof Walks.*

From the London Mechanics' Magazine, December, 1862.

But a new method of path-making is fast coming into vogue, and will soon be universally adopted for its cheapness, general excellence,

and permanence; in fact, when once well done, it lasts for ever. Instead of making the walk of loose material, on the old fashion, concreting is resorted to, by which the appearance of gravel is retained with all its freshness and beauty of contrast to grass and flowers, and the walk itself is rendered as dry and durable as the best pavement. The *modus operandi* is as follows:—Procure a sufficient quantity of the best Portland cement, then with the help of a laborer turn up the path with a pick, and have all the old gravel screened, so as to separate the loam and surface weeds from it, and to every six parts of the gravel add three parts of gritty sand of any kind—but soft pit sand is unsuitable—and one part by measure of Portland cement. When these are well mixed together in a dry state, add sufficient water to make the whole into a moderately stiff working consistence, and lay it down quickly two inches thick on a hard bottom. A common spade is the best tool with which to spread it; it must be at once spread, as it is to remain for ever, and a slight convexity given to the surface. In 48 hours it becomes as hard as a rock; not a drop of rain will go through it, and if a drop lodges on it, blame yourself for not having made the surface even; but a moderate fall is sufficient with such an impenetrable material. Not a weed will ever grow on a path so formed; not a worm will ever work through it; a birch broom will keep the surface clean and bright, and of course it never requires rolling. It is necessary to be very particular as to the quality of the cement, for a great deal of rubbish is sold under the name of real Portland. For the flooring of a green house, fowl-house, potting-shed, or barn, this is the best and cheapest that can be had—always clean, hard, and dry, and never requiring repairs of any kind if carefully put down in the first instance.—*Gardener's Weekly Magazine and Floricultural Cabinet.*

---

## *The First English Steamer.*

From the Lond. Mechanics' Magazine, December, 1862.

The *Margery* was built at Dumbarton, by the late Mr. W. Denny (father of the eminent firm of shipbuilders of that name, now also in Dumbarton), for W. Anderson, merchant, Glasgow, and when launched was christened the *Margery*, after his eldest daughter, who named her, and who is still alive, and at present a resident in London. At the close of 1814, Captain Curtis was sent by a London company to Glasgow, to negotiate with Mr. Anderson for the purchase of the *Margery*, which was effected, the only stipulation made by Mr. Anderson being that the name of the steamer should at no future time be changed; this Captain Curtis agreed to, and the promise was faithfully kept. Captain Curtis took the *Margery* through the Forth and Clyde Canal, and invited a large party of Mr. Anderson's friends to accompany him while passing through the canal, and was most hospitable in his

entertainment to them. There remain but two of this party now alive, viz: the lady after whom the steamer was named, and a clergyman, a friend of Mr. Anderson's. The writer of the article in the *Dumbarton Herald* is quite correct as to his statements of the fear and wonder which the appearance of the *Margery* excited on the coast, while on her passage to England, as well as among the English fleet; in most cases she was supposed to be a vessel on fire. The *Margery* was the first steamship that ever sailed in English waters, and made her first trip to Milton, below Gravesend, on the 23d January, 1815. She was ultimately taken to Paris, where not many years ago her timbers were still lying on the banks of the Seine. Mr. Anderson was, therefore, owner of the first steamer that was ever seen in London, and also in Paris; he also owned the first that ever crossed from Scotland to Ireland (viz: the *Greenock*, built soon after the *Margery*), which he took to Belfast; he also took the first to Londonderry—the *Princess Charlotte*. The late Mr. Anderson was grandfather to the Messrs. Gwynne, engineers, of Essex Street Wharves, whose large centrifugal pumping engine in the International Exhibition attracted so much admiration and attention during the past season.

---

For the Journal of the Franklin Institute.

## *On a National Academy of Science and Techonological Institutions.*

By JOHN W. NYSTROM, C. E.

It is very gratifying to know that Congress at its last session passed a bill to establish a *National Academy of Science*, which will no doubt be of great value to the country for the cultivation of the natural resources of our mind and for the improvement of our moral dignity and standing among nations in a political view, but at the same time, —considering the peculiar circumstances in which the country is now placed,—prosperity is of greater importance, and the former cannot be maintained without the latter. I am well convinced that we are behind some other nations in science, but am positively assured that we have more science in the country than we can properly manage; it is the *application of science to practice* which requires immediate attention and special institution.

In Europe they have institutions for the combined science and practice, the want of which is most severely felt in this country and for which we suffer most extremely. *A National Technological Institute*, with workshops and laboratories connected with Navy Yards and private establishments, are of more importance in this country than in Europe, for the reason that mechanical skill and inventive ingenuity are here more developed, and the want of applied science wastes away a proportionate quantity of time and money.

I may be mistaken, but am under the impression, that in the pre-

sent condition of our political system, an Academy of Science would not now answer the expected purpose, as it will a few years hence; while a Technological Institute would enable us to rise gradually and surely to the position due to us among nations, and when once so raised we would never fall.

I have adopted this country as my own, and care for its prosperity as much as any American that ever lived; my attempt to correct what I consider is wrong is in pure respect to you who came here a few days before me.

We have plenty of scientific books in the country, mostly written by Professors in Colleges, who have very little chance to apply their knowledge to practice, and are therefore destitute of practical examples. We oftentimes find most valuable formulas given by scientific men in such a shape that it requires to know as much or more than the author to employ them; they are not only not trained to a practical shape, but the meaning of letters are rarely explained in a technical language. It is surprising to see how excellently mathematicians have succeeded in keeping the simple science of the Calculus in such a perfect mystery; it reaches very few among us, not for the difficulty of learning it, but simply for the want of its application to practice. We find books on the Calculus of several hundred pages, and not a single practical example, which makes the science very difficult and tedious to learn, and when acquired, very rarely further developed, but stored away in the head so that it cannot be found when wanted.

We find simple formulas occupying several pages in explanation, which by a simple example applied to practice would by a few lines print it in the student so that he would never forget it. *A National Technological Institute* of high order would effectually remove such deficiencies.

Up to the present day the knowledge of steam-engineering is far behind our knowledge of science, for which the country suffers extremely. Our marine engines and boilers are not only unnecessarily complicated, but most extravagant in the consumption of fuel; our locomotive engineers ought to be ashamed of themselves when they come with their thunder-storm blowing out smoke and fire to suffocate passengers and set fire to houses and forests, which evil could be so advantageously employed to the general interest. My statements are not based on mere supposition, but on knowledge and experience; I know what I have seen, what I have done, and what you are doing, and will point out the evil if called for, but here is not the place to describe it.

Only a few years ago there was not a single propeller steamer in the United States with properly constructed air-pumps and foot-valves, for the want of knowledge of the physical laws by which it operates; errors of the same kind were committed in England and other countries. Propeller steamers designed to go to Europe succeeded some of them to make one passage, and some broke down at but a short

distance from the American shore and returned; most of those steamers existed but a short time. I will give names and describe the cases if necessary,—the U. S. Steamer *San Jacinto* was one of the number. When I saw the evil I worked out practical formulas and published the physical laws by which it operates, after which the errors in the air-pumps and foot-valves were corrected. I believe myself to be the first one who has worked out that theory when there was no publication of that kind in the whole world.

Had the subject of the expansion and other properties of steam been understood by the engineers in the Navy, it would have saved the Erie expansion experiments, and our men-of-war lately built would have given better satisfaction. I was the first one to prove the folly of the Erie expansion experiment, and published an article on the same in the *Scientific American* in January, 1861, but omitted to explain what deceived Mr. Isherwood in the experiments made on the stationary engine in New York. There is yet no publication so complete with practical formulas and tables of the expansion of steam, its economy and application to different kinds of engines, as that of my Pocket Book, which has been partly copied in Europe.

The knowledge of steamship performance has until lately been on a very low point. Steamship contractors have often bound themselves to accomplish more than established by physical laws, and the Navy Department has bound contractors with impossibilities for the want of proper knowledge of steamship performance. A few years ago an engineer imposed on the public some exaggerated statements of steamship performance, which I attempted to correct, but was overwhelmed with mystical proofs in aid of the exaggerations; a short time after the performance the steamer in question turned out a failure and disgrace to the country. There is yet no publication with so reliable datas of steamship performance as that in my Pocket Book. I could point out thousands of cases where blunders were made in practice for the want of appreciation of, and disrespect to the science in our possession, but am afraid to be misunderstood, although I am well convinced that for the general interest many will consider it their agreeable duty to give my views a liberal consideration.

---

Translated for the Journal of the Franklin Institute.

## *On some New Properties of Sulphur.* By M. DIETZENBACHER.

### *Note Presented to the Academy of Sciences of Paris.* By M. H. SAINTE-CLAIRE DEVILLE.

A small quantity of iodine, bromine, or fluorine modifies the physical and chemical properties of sulphur in a very remarkable way. The sulphur becomes soft, malleable at ordinary temperatures, and retains these properties for a considerable time. It is, moreover, partly or entirely transformed into that curious modification of sulphur discovered by *M. Charles Sainte-Claire Deville*, and called by him *insoluble sulphur*.

1st. By heating to about 180° (356° Fahr.) a mixture of 400 parts of sulphur with one of iodine, there is procured on cooling a sulphur which remains for a long time elastic. It may be obtained in flexible sheets by casting the sulphur upon a glass or porcelain plate.

This property shows itself with even a much smaller proportion of iodine. The iodide of potassium acts in the same way as iodine. The sulphur thus treated becomes insoluble in the sulphuret of carbon. The liquid assumes a violet color.

2d. The action of bromine on sulphur is analogous to that of iodine, only that in place of a sulphur with a black color and metallic lustre, there is obtained a sulphur of a wax-yellow color much softer than the other: this state is lasting. One per cent. of bromine and a temperature of 200° (392° Fahr.) will give this modification. This sulphur contains from 75 to 80 per cent. of sulphur insoluble in sulphuret of carbon.

3d. By passing a current of chlorine through sulphur brought to a temperature of 240° (464° Fahr.), there is obtained a kind of sulphur which is easily drawn out in threads, and the pieces of which can be kneaded together.

With sulphuret of carbon it behaves in the same way as the sulphur treated with bromine. But when freshly prepared it yields 10 per cent. more to the liquid. After being kneaded for an hour or two this sulphur suddenly hardens, and becomes completely insoluble in sulphuret of carbon.

These facts may serve to explain certain details of the manufacture of vulcanized india-rubber by means of sulphur and its chloride. Some of them confirm results before obtained by M. Beolthelet.

*Comptes Rendus*, 5th Jan. 1863.

---

For the Journal of the Franklin Institute.

## *The Propeller Niphon.*

Hull built and vessel owned by Capt. R. B. Forbes, Boston, Mass. Machinery constructed by Atlantic Works, Boston. Route of service, Coasts of China and Japan.

*Hull.*—Length between perpendiculars, 154 ft. Do. over all, 157 ft. 6 ins. Breadth of beam, (extreme), 25 ft. 6 ins. Depth of hold, 9 ft. 6 ins. Do. to spar-deck, 16 ft. Draft of water, (light),—forward, 7 ft.—aft, 10 ft. Do. (loaded), forward, 8 ft. 6 ins. —aft. 11 ft. 6 ins. Rig, Barkentine. Tonnage, 475 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 26 ins. Length of stroke of piston, 2 ft. 2 ins. Length of propeller shaft, 32 ft. Diameter of do., 8 ins.

*Boilers.*—One—return flue. Length, 25 ft. Diameter of shell, 10 ft. Fire surface, 1600 sq. ft. Grate surface, 64 sq. ft. Coal consumed per day, 13 tons. Is fitted with a blower.

*Propeller.*—Diameter, 9 ft. Blades, 4. Material, iron.

*Remarks.*—The ends of this vessel are long and sharp, with slightly concave lines; the stem is nearly upright and handsomely curved in

the wake of the forefoot, and her stern is semi-elliptical and well proportioned. Viewed broadside on she presents a lively sheer graduated her whole length, and as great care has been bestowed in the regularity of her planking, she looks finely. She has 10 inches dead rise at half-floor, and to strengthen her bilges, and aid her in holding on by the wind, and prevent her from rolling when going free, she has bilge-strakes 60 feet long which extend outside of the planking 6½ inches, in all ten inches thick, and these are tapered toward the end to blend with the hull.

Her partner beams are 15 feet by 10, boiler-hatch beams, 10 feet by 7, and all others in the lower deck frame are 7 feet by 7—they are 3 feet apart—of hacmetac. The deck is of white pine, 3 inches thick. The upper deck frame is of hacmetac; the hatch-beams, mast-beams, and forecastle-beams are 8 inches by 4½, the balance 5 inches by 4½, and 2 feet apart. The deck is of white pine, 2½ inches thick. The lower deck water-way is 12 inches by 10, ceiling in between-decks 1¾ inches, spirketing 6 inches high, and plank-sheer 4½ inches—of pine; the top of the plank-sheer is 17 or 18 inches above deck. The top timbers are 8 inches by 5, tapering to 8 inches by 4½, and 8 inches apart; of hacmetac. The outer plankings or bulwarks, from the plank-sheer to the upper deck, are of 2-inch pine, excepting on the round of the stern and on the bow, where they are of oak. The stem, sided, 12 inches, and stern posts, 13 inches, are of oak, also the knightheads; the keel of rock maple, one length, and two of white oak, 12½ inches and 12, with lock scarphs 10 feet and 3 inches shoe.

The frame or ribs of this vessel are of Pembroke angle iron, 3½ inches by 2½, and ½-inch thick, extending all in one piece from the keel to gunwale; they are but 16 inches from centre to centre. The cross floors consist of reversed angle iron, and $\frac{5}{16}$-inch thick plate in wake of engine and boiler, on every frame, and elsewhere plate with angle iron on every alternate frame. There is a water-tight iron bulkhead, ¼-inch thick, stiffened by nine vertical angle irons at the main-mast, to which the boiler and coal bunkers of iron extend; another similar bulkhead about 16 feet from the stem, and also one abaft the engines, 10 or 12 feet forward of stern post, thus dividing the vessel into four water-tight compartments. The main keelson, riveted to every floor, consists of two angle irons, 3 feet by 3 feet 6 inches, and running through the main bulkhead to the engine floors, which are four feet high above the keel. Instead of ceiling, there is a system of bracings of 3 inches by ⅝ths bar iron, crossing each other diagonally, and about three feet apart. This strapping, or diagonal bracing, is securely fastened to a heavy stringer plate, 6 inches wide by ¾ thick, running fore and aft at the lower part of the plate iron knees, which are attached to the beams by screw bolts and nuts; the lower ends of the strapping are firmly riveted to a bar keelson, 4½ by ⅝ inches, attached to the cross floor heads by double rivets. The planking of the vessel is of the best white oak; the garboard strake 5 inches thick, bolted edgewise to the keel at the distance of four feet, the second

strake is 4 inches, and all the rest to plankshear 3½ inches. This planking is fastened to the angle iron ribs, by galvanized iron bolts with round heads, having a square shoulder ⅜ of an inch from the head toward the screw ends; these bolts are driven from the outside through the ribs, and finally set up by galvanized nuts on the inside of the angle iron ribs. Between the oak plank and the frames there are strips of tarred felt, and elsewhere wherever oak and iron came in contact.

The rig of this vessel is peculiar, and may be called a "barkentine;" but it differs from the usual rig so-called, inasmuch as the square sails are on the mainmast, the fore and mizzen being fore-and-aft rig with boom sails and gaff topsails; the fore stay-sail or main jib sets on a stay setting up to the knightheads; the bowsprit is really nothing more than a jibboom, on which sets a sail, the stay of which goes to the masthead close up to the fore cap, and to the topmast there sets a jib topsail.

The dimensions of the spars, &c., are as follows: Foremast above deck, 60 feet; head, 10 feet; diameter, 19 inches; rake, 1 inch to the foot; distance from outer part of stem, 34 feet; topmast, 42 feet; pole, 8 feet; foreboom, 41 feet; gaff, 29 feet. Mainmast, 45 feet from the foremast; 51 feet 6 inches above deck; rake, 1 inch to the foot; head, 12 feet 6 inches; diameter, 20 inches; topmast, 25 feet 6 ins.; topgallant, 15 feet; royal, 11 feet, and pole, 5 feet; total, 56 feet 6 inches, all in one stick. Main yard, 52 feet; topsail yard, 39 feet; topgallant, 29 feet; royal, 20 feet 6 inches. On this mast there is no square mainsail, only a small storm spencer, fitted to brail to the mast. The mizzen is 45 feet 6 inches from the mainmast, and is 60 feet above deck, with 8 feet head, and a topmast on which is set a flying gaff topsail and a stay-sail. The topmast is 32 feet; mizzen boom, 41 feet; gaff, 23 feet. As the smoke pipe comes up in the centre of the space between the main and mizzenmasts; this is the only way by which sufficient canvass can be safely carried on the mainmast. The rig is certainly novel and unique, and will doubtless propel as well and work as well as the regular barkentine.

As the fastenings of the bottom plank are of galvanized iron, countersunk three-fourths of an inch, and well plugged, when the bottom is well covered by felt laid on "half stuff," the composition will wear as well as on a purely wooden ship and insure a clean bottom.

The advantages of the mode of building as adopted in the *Niphon*, are a good combination of lightness and strength, greater durability, especially in hot climates, than if the vessel was built wholly of wood, greater carrying capacity, better ventilation, and consequently more healthy than a wooden ship; ability to get at a leak, large or small, from the inside, when not full of cargo; no stowage for vermin; easily repaired. She has two important advantages over iron vessels; first, the absence of condensed vapor, which always takes place in iron vessels, making them cold in cold weather, and hot in warm weather; and secondly, the bottom being coppered will keep clean better. In short, there can be no doubt of the superiority of this

mode of building over wood, and of its being, taking all things into consideration, as good as all iron. For light draft war-vessels, it is very superior to all wood, as the amount of weight saved will enable them to be plated in the wake of machinery sufficiently thick to keep out many of the lesser projectiles.

In regard to the mode of constructing vessels by a combination of wood and iron, as adopted by Capt. Forbes in this instance, though not identical, it is on the same general principle as that used and patented by Capt. R. F. Loper, of Philadelphia, some fourteen years since. B.

---

For the Journal of the Franklin Institute.

## *Particulars of the Barque Tycoon.*

Hull built and vessel owned by Charles Mallory, Mystic, Conn.

Hull.—Length between perpendiculars, 152 ft. Do. over all, 172 ft. Breadth of beam, 35 ft. Depth of hold, 16 ft. 8 ins. Frame of white oak and chestnut; planked with oak and yellow pine; oak bottom; yellow pine ceiling; securely fastened with copper. Tonnage 850 tons.

Masts, Yards, &c.—Foremast—whole length, 61 ft.; size, 24 ins.; head, 12 ft. Mainmast—whole length, 63 ft.; size, 25 ins.; head, 12 ft. Mizzenmast—whole length, 61 ft.; size, 18 ins.; head, 9 ft. Fore and main topmasts, 35 ft; size, 13 ins; head, 6½ ft. Mizzen topmasts, 30 ft.; size, 11 ins. Mizzen topgallantmast, 12 ft.; pole, 6 ft. Fore and main topgallantmast, 22 ft.; size, 9 ins. Fore and main royal mast, 12 ft.; pole, 6 ft. Fore and main yards, whole length, 60 ft; size, 15 ins.; arms, 3 ft. Upper topsail yards, whole length, 48 ft; size, 11½ ins.; arms, 2½ ft. Lower topsail yards, whole length, 52 ft.; size, 12½ ins.; arms, 1 ft. Topgallant yards, whole length, 36 ft.; size, 8 ins.; arms, 1 ft. Royal yards, whole length, 29 ft.; size, 6 ins; arms, 1 ft. Gaff, whole length, 30 ft.; size, 6½ ins.; end, 4 ft. Spanker boom, whole length, 37 ft.; size, 8 ins.; end, 2 ft. Jib boom, 15 ft.; size, 13 ins. Bowsprit, outboard, 10 ft. B.

---

For the Journal of the Franklin Institute.

## *Particulars of the Side-wheel Steamer C. W. Thomas.*

Hull built by Mr. Rufus W. Cushman. Machinery constructed by Mr. R. S. De Mott. Commander, Captain A. W. Davidson. Owners, Messrs. McKay & Aldus.

Hull.—Length on deck, 137 ft.; breadth (inside of guards), 22 ft. 7 ins.; do. (outside), 36 ft. Depth of hold, 8 ft. 4 ins. Draft of water at load line, 4 ft. 6 ins. Tonnage, 254 tons.

Engines.—Vertical beam. Diameter of cylinder, 28 ins. Length of stroke of piston, 7 ft. 6 ins.

Boilers.—Return tubular. Uses a blower.

Water-wheels.—Diameter, 21 ft. 6 ins.; face of do., 4 ft. 6 ins.

*Remarks.*—As this is the first side-wheel steamer built in a private yard in Boston, a description of her will not be uninteresting. This vessel has very concave lines forward, a long sharp bow, and a rounded stern. Her frame, ceiling, and planking are of seasoned white

oak, square fastened throughout, and through tree-nailed with locust, and screw-bolted in her heaviest planking and clamps. The keel is of rock maple, 12 inches square; the floor timbers 5 by 9 inches, and her keelsons—of which she has five—are from 12 inches square to 10 by 12, all bolted through and through. Her clamps and bilge strakes are 4 by 14 inches; the clamps are set up with screw bolts. The garboards are also 4 inches thick, and the rest of the planking and ceiling are 2½ inches, all of oak. The beams amidships are 10 by 12 inches, diminishing by regular gradation toward the ends. It will thus be seen that this vessel is strongly built.

The *C. W. Thomas* has two decks. Under the first is her dining saloon forward of the boilers, with store-rooms, and other apartments, and aft several state-rooms, &c. On this deck she has a saloon which is a gem of neatness—spacious, well lighted and ventilated, and gorgeously furnished. On the second deck are several spacious state-rooms, designed to be occupied by her captain and officers.

This vessel was designed and modeled by Mr. Nathaniel McKay, brother of the well known naval architect, Donald McKay, of Boston.

Upon the trial trip of this steamer, everything worked satisfactorily, and her performance demonstrated to all then with her that she was a success. B.

---

## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, March* 18, 1863.

John Agnew, Vice President, in the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, the Royal Society, the Institution of Civil Engineers, and the Society of Arts, London; l'Ecole des Mines, Paris, et la Société Industrielle de Mulhouse, France; Der Nieder-Osterreichischen Gewerbe-Vereines, Wien, Austria, Dr. E. M. Dingler, Augsburgh, Germany; the Canadian Institute, Toronto, and Major L. A. Huguet-Latour, Montreal, Canada; Hon. John Cradlebaugh, Lieut. Col. C. C. Tevis, and Charles Colné, Esq., Washington, D. C.; the Board of Water Commissioners, Detroit, Michigan; the New York State Lunatic Asylum, Utica, Prof. James Hall. Albany, the Chamber of Commerce of the State of New York, and Capt. E. B. Hunt, New York; T. C. Zulich, Harrisburgh, Prof. John F. Frazer, Prof. John C. Cresson, Isaac S. Cassin, Esq., and the Pennsylvania Institution for the Blind, Philadelphia, Pennsylvania.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of February was read.

The Board of Managers and Standing Committees reported their minutes.

The Actuary reported that the following Standing Committees have organized by electing their Chairman, and appointing their times for meeting, viz:

| *Committee.* | *Chairman.* | *Time of Meeting.* |
|---|---|---|
| On Models, | James Agnew, | 1st Monday evening. |
| " Library, | John Ferguson, | 1st Tuesday " |
| " Exhibitions, | John E. Addicks, | 1st Friday " |

Candidates for membership in the Institute (5) were proposed, and the candidates proposed at the last meeting (9) were duly elected.

Mr. Howson exhibited diagrams and models of A. B. Cooley's apparatus for obstructing rivers, consisting of a series of blocks or frames chained together, and anchored at each end of the series to one of the sides or shores of the river. Each block resembles a tetrahedron in shape (the points being tipped with iron or steel), so that upon whatever side the block may lie, a sharp apex will be presented, which should be about five feet below the surface of the stream. The blocks are at such a distance apart that no war vessel of formidable size can pass through the channel without coming in contact with one or other of the frames. When no longer required to obstruct the channel, the blocks may be disconnected and separately removed.

Mr. Howson also exhibited several breech-loading fire-arms. The first is the invention of L. H. Gibbs, and manufactured by W. F. Brooks, of New York. In this arm the trigger guard is used as a lever, on depressing which the barrel is thrown forward, and tilted up at the rear, so as to expose the breech ready to receive a load. Another arm, the invention of B. F. Joslyn, of Connecticut, is closed at the breech by a cap hinged to the side and rear of the barrel, and is so constructed as to automatically discharge the empty cartridge case from the gun, on unclosing the breech.

H. Liebert's substitute for gunpowder was exhibited. Its principal ingredients are prussiate of potash and cyanide or ferro-cyanide of potassium. A powder composed of these two substances, in combination with nitrate of soda, charcoal, sulphur, and other ingredients, any or all of which may be employed, can be compounded without that danger of explosion which is incurred in making the ordinary substitutes for gunpowder, in which chlorate of potash is generally used.

Mr. J. N. Pierce, of Darby, Delaware Co., Pa., exhibited numerous specimens of artificial slate, for the use of schools, colleges, &c. On painting any suitable surface with a preparation, patented by Mr. P., a slate-colored ground will be formed which answers equally as well as slate for drafting or marking purposes. Paper, linen, or any textile fabric may be used to form convenient portable slates, which can be rolled or folded up for transportation.

Mr. P. also exhibited pencils made of talc.

Mr. E. Brady exhibited his Patent Mode of Attaching Armor to Vessels.

**Mr. Washinton Jones exhibited specimens of gunpowder similar to that which exploded at Wilmington, Delaware, a few days since.**

Mr. Nystrom exhibited some tools and instruments, namely, a Lathe, Square, Compasses, Callippers, Telescope, Dioptric Rule, Hand Vices, Stocks and Dies, Inkstand, Pentograph, Drillstock, &c., about twenty-five pieces, and made the following remarks:—I have brought to the meeting this evening some tools and instruments made by myself while a student of the Royal Technological Institute, Stockholm. I have not brought them here to show you something new in design or workmanship; they are, I believe, most of them familiar to you; but my object is to call your attention to how men are brought up and how Technological Institutions are arranged in Europe. The U. S. Congress has passed a bill to establish a National Academy of Science, about which I have written an article for the *Journal*, which will appear in the next (April) number. In that article I endeavor to show the necessity of a National Technological Institute of high order in preference to an Academy of Science.

The Royal Technological Institute, Stockholm, where I have made these instruments, have drawing room, machine shop, pattern shop, blacksmith, tinsmith, and chemical laboratory connected with it, where the students work between lecture hours. It is not expected, neither is it necessary, that the student shall become an accomplished mechanic, but the object is to turn his mind on the work about which he is studying and calculating; when confined to only books and blackboards his imagination very rarely extends any further; he acquires the knowledge mechanically, as it were,—the study becomes tedious to him, and when brought to bear on practice the most simple problem may confuse him. When the student is brought up in the combined theory and practice, he acquires taste for work, good workmanship, and proper proportions, and the application of his science becomes a pleasure to him; he studies mathematics at the same time he learns to draw, physics and mechanics at the same time he makes his tools and models for machinery; his science is applied as fast as he acquires it, and he will never forget it. I made a great many models at the institute, and you will see my tools are pretty well worn. When I studied optics, I made optical instruments, of which I have brought two here, one a telescope and the other a dioptric rule. The rule may be something new to you, and I will explain its operation. On the one end, as you see, is mounted a round glass, the plan of which is at right angles to the rule; half the glass is transparent and the other half a looking-glass; when placed in position on the board I look through the glass so that I see the pupil of my eye in the centre of the looking-glass and at the same time look through the transparent part on the object; when the rule is properly adjusted the line is drawn on the board. When I studied acoustics, I made musical instruments, the drawings of which are in this book, containing nearly 200 drawings of machinery which I made at the Institute.

Another instrument which may be new to you is a scriber, by which

to scribe concentric circles around a hole without knowing its centre; as you see, there is a cone on the one leg which is placed in the hole, while the other leg scribes the circle. I wish to be distinctly understood, that I have not brought these tools to the meeting to show what I can do or how smart I am, but simply to impress upon you the necessity and importance of a Technological Institute in this country.

There are also institutions in Sweden in connexion with private establishments, where the student finishes his practical training. I finished mine under Captain Carlsund Motala. When a student is so brought up, he is able to make himself useful and bring his science to bear on the general interest.

America has taken the lead of the world in popular education; its institutions are copied into Europe; but it remains to follow up and take the lead in the nobler and purer refinement of our nature. We have the best materials on the globe by which to accomplish that object; the question is only time and what course to be taken. There is now a very distinct line drawn between practical and scientific men; the more we cultivate the branches separately the more distinct will the line be, the less will we understand one another, and without the aid of Technological Institutions we may ultimately fall to the low grade of our present politicians, to make speeches against one another and call one another by nicknames. A chain cannot hang together if one link is wanted, and it is the wanted link which I am endeavoring to repair.

---

## BIBLIOGRAPHICAL NOTICES.

*Report on the Geology and Agriculture of the State of Mississippi.* By EUGENE W. HILGARD, Ph. D., State Geologist. Printed by order of the Legislature. E. BARKSDALE, Jackson, Miss., 1860.

A plain practical exposition of the scientific and practical results of a survey made for the purpose of developing the mineral and agricultural resources of the State of Mississippi. The author in his preface has thought it necessary to defend his scientific language and scientific detail, but it is to be hoped, that the painful circumstances which have occurred since the book was written will give him a more extended audience and one before whom no such defence is needed. On the other hand, were we disposed to find fault, it would be by admonishing him that the duty of a writer on a scientific subject is twofold—first, to make his subject as easy of comprehension and as pleasant to peruse as his talents and the nature of the subject will permit; but always remembering, in the second place, that scientific precision must not be sacrificed to popularity, and that his duty is not only to gratify but also to correct and raise the public taste. We would not in a popular treatise speak of water as the *protoxide of hydrogen*, nor complain of a popular bivalve being called oyster in place of a more latinic name;

but we do object to the calling our tulip tree a poplar, which Mr. Hilgard knows and admits that it is not; as we protest against the vulgarity of naming our magnificent Buttonwood tree after the commonplace European Sycamore. (Do not let it be implied that this error occurs in Mr. Hilgard's report.)

The report contains a great deal of information interesting partly to the scientific, partly to the practical man. The resources of the State, while they want the richness of some of the middle regions of our Union, are valuable and well worthy of the development which we hope will follow the present political convulsions. F.

---

*Union Foundations a Study of American Nationality as a fact of Science.* By Capt. E. B. HUNT, Corps of Engineers, U. S. A. New York, Van Nostrand, 1863, 8 vo. pp. 61.

The gist of this pamphlet is an argument drawn from the physical geography and statistics of our country, that its separation into fragments is a moral if not physical impossibility, or that, in other words, the cost and inconveniences of a separation are indefinitely greater than those of any war for the maintenance of unity. The data of the argument are excellently stated and clearly developed, and if any one needs an argument on this point they could not wish a better than is here given. But it never has seemed to us that this was the true question. With the exception of a few fanatics on each side, we believe the whole people of the United States are convinced of the necessity and determined in favor of union. The true and only question is under whose authority? under what constitution? Mr. Jefferson Davis or Mr. President Lincoln? under the constitution of our forefathers or that known as the Montgomery? On this point our pamphlet expresses itself by implication only, but apparently on the loyal and logical side. Into this question (if there be any among honest and intelligent men) our *Journal* will not enter for fear of politics, and abstains the more readily as the matter appears to be practically settled.

— F.

*First Outlines of a Dictionary of the Solubilities of Chemical Substances.* By Frank H. Stover. Part I. Cambridge, Sever & Francis, pp. 232 and appendix.

It is difficult to convey a sufficient opinion of the value of this unpretending writer. Practical and experimenting chemists will alone fully appreciate its value, and from its very nature it is scarcely possible to make extracts from it. The solubility of substances are so intimately connected with their other chemical properties that this work will be indispensable to every one concerned with chemistry.

---

ERRATA.

"Burlington Tunnel." Vol. xliv., Dec. 1862, page 377, line 10, for "contract price the work was $60,000," read "$30,000."

"Strength of Cast Iron Timber Pillars." Vol. xlv. March, 1863, page 180, bottom line, for "supported by pillars 6 inches diam.," read "supported pillars 6 inches diam."

*A Comparison of some of the Meteorological Phenomena of* FEB., 1863, *with those of* FEB., 1862, *and of the same month for* TWELVE *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

| | February, 1863. | February, 1862. | February, 12 Years. |
|---|---|---|---|
| Thermometer—Highest—degree, | 54·00° | 52 00° | 70·00 ′ |
| " " date, . . | 10th. | 13th. | 23d, 1860. |
| " Warmest day—Mean, | 46·00 | 42·2 | 59·3 |
| " " " date, | 27th. | 13th. | 25th, 1857. |
| " Lowest, degree, . | 5·00 | 16·0 | — 1·0 |
| " " date, . | 5th. | 10th. | 7, '55. 8, '61. |
| " Coldest day—Mean, | 11·17 | 22·8 | 5·7 |
| " " " date, | 4th. | 10th. | 7th, 1855. |
| " Mean daily oscillation, | 13·57 | 10·89 | 13·41 |
| " " " range, | 7·54 | 5·55 | 7·30 |
| " Means at 7 A. M., . | 30·46 | 28·36 | 29·25 |
| " " 2 P. M., | 37·70 | 36·00 | 38 38 |
| " " 9 P. M., . | 34·04 | 31·64 | 33·43 |
| " " for the Month, | 34·07 | 32·00 | 33 69 |
| Barometer—Highest—Inches, . | 30 671 in. | 30·322 in. | 30·671 in. |
| " " date, . | 4th. | 16th. | 4th, 1863. |
| " Greatest mean daily press., | 30·537 | 30·253 | 30·595 |
| " " date, . | 4th. | 16th. | 12th, 1857. |
| " Lowest—Inches, . | 29 345 | 29·216 | 29·065 |
| " " date, . | 20th. | 24th. | 23d, 1853. |
| " Least mean daily pressure, | 29·501 | 29·454 | 29 227 |
| " " date, . | 20th. | 24th. | 16th, 1856. |
| " Mean daily range, . | 0·265 | 0·225 | 0·224 |
| " Means at 7 A. M., . | 30·031 | 29·939 | 29 930 |
| " " 2 P. M., . | 29·977 | 29·891 | 29 882 |
| " " 9 P. M., . | 30 024 | 29·922 | 29·913 |
| " " for the Month, | 30·011 | 29 917 | 29 908 |
| Force of Vapor—Greatest—Inches, | 0·322in. | 0·267 in. | 0·549 in. |
| " " " date, . | 6th. | 24th. | 16th, 1857. |
| " " Least—Inches, | ·027 | ·060 | ·013 |
| " " " date, . | 4th. | 25th. | 6th, 1855. |
| " " Means at 7 A. M., | ·142 | ·130 | ·140 |
| " " " 2 P. M., | ·149 | ·143 | ·162 |
| " " " 9 P. M., | ·146 | ·142 | ·159 |
| " " " for the month, | ·146 | ·138 | ·154 |
| Relative Humidity—Greatest per cent., | 100· per ct. | 100 per ct. | 100 per ct. |
| " " " date, . | 19th. | 24th. | Often. |
| " " Least per cent, | 29·0 | 44·0 | 25·0 |
| " " " date, . | 16th. | 28th. | 21st, 1861. |
| " " Means at 7 A. M., | 77·3 | 80·4 | 79·4 |
| " " " 2 P. M., | 63·5 | 66·6 | 64·6 |
| " " " 9 P. M., | 70·9 | 77·9 | 76·3 |
| " " " for the month, | 70·5 | 75·0 | 73·4 |
| Clouds—Number of Clear days,* . | 7 | 3 | 8· |
| " " Cloudy days, | 21 | 25 | 20· |
| " Means of sky cov'd at 7 A. M., | 73·6 per ct. | 76·1 per ct. | 62 6 per ct |
| " " " " 2 P. M., | 62·9 | 73·2 | 60 8 |
| " " " " 9 P. M., | 63·9 | 61·1 | 47 1 |
| " " " for the month, | 66·8 | 70·1 | 56·9 |
| Rain and melted Snow—Amount . | 3·824 in. | 4·277 in. | 2·899 in. |
| No. of days on which Rain or Snow fell, | 13· | 15· | 10·4 |
| Prevailing Winds, . . | s56°19′w.·139 | s45°0′ w. ·208 | s.69°50′w·278 |

* Less than one-third covered at the hours of observation.